Dynamic Order Dressing – the Key Input to Optimized Planning

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Summary

Metals producers with complex routings are relying on complex planning solutions to manage their plants. In order to do so they require a sophisticated order book as an input and a reactive component to handle potential deviations from the plan. This paper explains how using Dynamic Order Dressing can help with both aspects.
Production Order (PO) Variants can be determined dynamically during the Material Demand calculation. At each decision point, additional PO Variants are induced, if the routing decision return multiple alternatives. Furthermore, PO chains could be generated, either breaking long routes into segments or dynamically creating Main and Auxiliary PO's, whereby firstly the Main PO is calculated to determine the exact intermediate and final materials, before the Auxiliary PO is calculated accordingly. Finally, Due Date Quoting (DDQ) evaluates all PO Variants, determines their potential due date, and selects the best PO Variant according to optimization criteria. At later time, Material Allocation is executed, preferably using the primary Material Demand Variant of the PO Variant selected by DDQ. The additional Variants provided by Dynamic Order Dressing, however, extend the room for solutions significantly, reducing unassigned stocks for the plant. This comes especially handy when a plant purchases many intermediate materials of different dimensions externally. Once such alternative intermediate material design is selected for allocation, this will automatically trigger a Material PO generated by Forward Dressing to ensure optimal routing, production and quality instructions for this non-standard material.

Introduction

Since solutions that are more traditional use static Bill of Materials and routing definitions, they can only provide limited or no support for alternative routings in complex scenarios. However, modern Planning applications have ever-growing requirements regarding the order book provided as main input. Furthermore, production deviations ask for flexible generation of adjusted downstream PO's.

Dynamic Order Dressing (OD) has several advanced features, which when combined into the proper overall system architecture can make the difference:

- The Sales Order Item (SOI) is elaborated into multiple alternative Production Order (PO) variants, each of which represents an individual alternative routing.
- Within each PO variant OD calculates multiple Material Demand Variants (modelling alternative dimensions, according yield and cutting factors) in fully configurable mathematical models.
- Material Demand Variants could either lead to additional PO variants or stored as alternative Material Demand Variants separately (e.g. used for Allocation applications).
- After the Main PO is fully calculated, potential Auxiliary PO's (e.g. Auxiliary Coupling PO for a Main Pipe PO) are calculated in a loop.
- Forward Dressing as reactive solution provides custom fit Material specific PO's (MAT PO's) for allocated non-standard or out of quality specification materials.

The following paragraphs will highlight each of these key features.

Dynamic Order Dressing – Alternative Routings

The starting step for Order Dressing is the receipt of a dressing request, usually the receipt of a SOI (Demand) for a specific Finished Good (FG) from ERP.
Such dressing request will lead to the initial PO Generation, creating all potential routes, typically modelled as PO Variants.
Alternative routes combine feasible plants and shops, as well as different successive PO steps/lines within the same shop (for instance in PO Variant 1 and 4 the Shop "Cold Finish" for Plant A uses a different sequence of PO steps and lines and hence represent another routing alternative) as shown in below Figure 1: "PO network with PO variants".

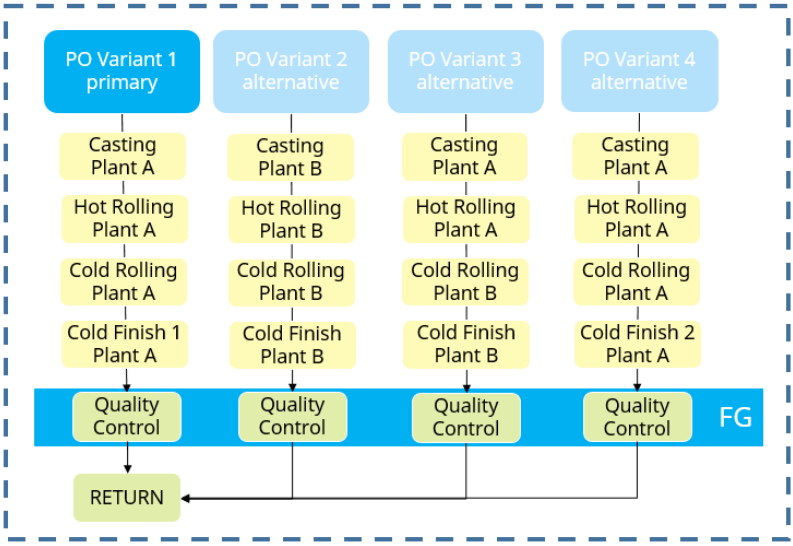

Figure 1: PO network with PO variants

What are PO Variants?

- PO Variants are separate PO's that model production alternatives, often related to alternative routings and sometimes to alternative intermediate materials.
- PO Variants must be linked for balancing reasons. So typically, you have a primary route with an additional Virtual RETURN step that takes in the weight of the additional PO Variants and therefore is the master for the PO balancing.
- High Level Planning selects the active PO variant, however it is possible to manually adjust the decision later. It is also possible to distribute partial quantities on different PO Variants for execution (especially on bigger orders).

How can one obtain alternative routings?

1. Static routings (see below figure 2):

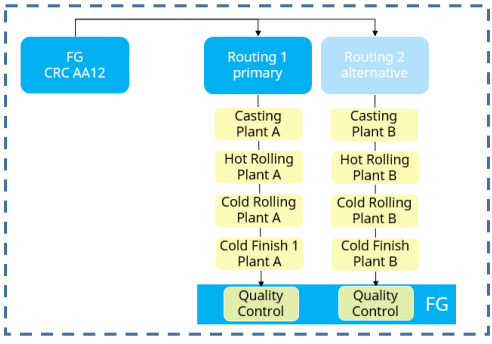

Figure 2: Static routings

Routings are defined as static objects and linked to FG products. Even so, this could include alternative routings, they have to be pre-defined by the engineering team. At runtime the routing is copied like a template and used for the PO. This approach is often used in traditional ERP systems and supports only low complexity, as the management of FG's and assigned routings can easily grow into huge numbers and is difficult to manage.

2. Pre-determined / semi-dynamic routings (see below figure 3):

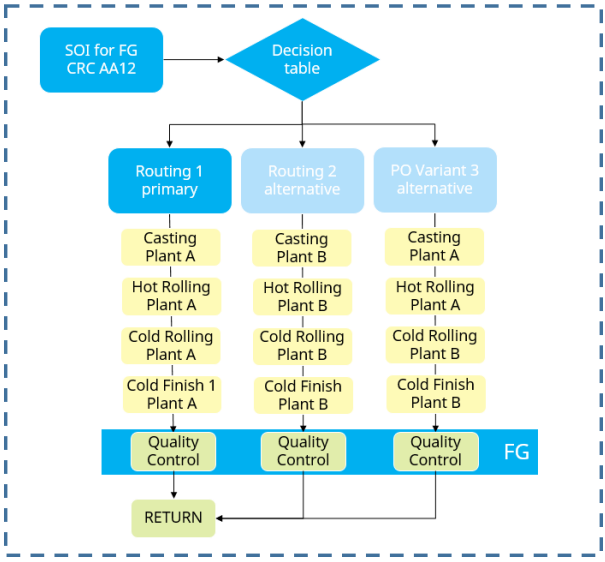

Figure 3: Pre-determined / semi-dynamic routings

Based on the SOI (e.g. classification, standard, grade, special treatments and dimensions) a preliminary decision is taken to enable certain alternatives. At this stage you are limited to SOI level information, for instance you do not know the exact intermediate materials, cutting plan or feasible lines. However, you do know that you can produce this kind of FG product in Plant A and B and where the typical (roughly standardized) input material can be produced and therefore can take reasonable decisions up to a certain degree (add Option 3).

3. Dynamically determined routings (see below figure 4):

During the course of the material demand calculation, the engine hits decision nodes that can branch out the defined macro routings into routing alternatives. If the condition behind such decision node returns more than one option, the PO variant are increased accordingly (see the red/white "+" symbol in below figure 4). You can furthermore eliminate options that are either not feasible or not preferred (e.g. forbid jumping too often between far distant shops).

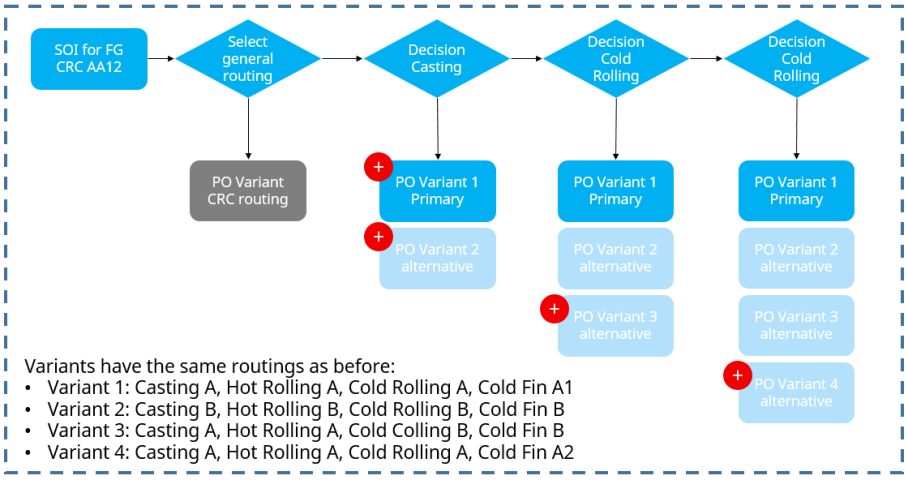

Figure 4: Dynamic routings

4. Post-determined routings (see below figure 5):

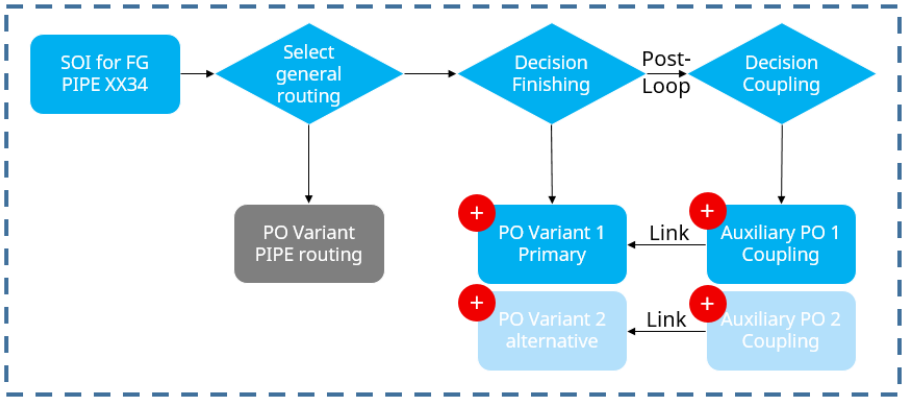

Figure 5: Dynamic routings

In some cases, additional Production Orders are required to manage by-products or auxiliary materials that need to be produced and consumed by the Main Production Order at certain step and therefore need to be planned and scheduled upfront. For instance in pipe business you need to determine the exact pipes (amount and dimensions) in order to determine the required amount of pieces of couplings since the pipe length is typically highly variable. Also in case of sandwich plates or cladded aluminium sheets, you first need to determine the precise intermediate material of the main PO (Variants), for which you can then calculate additional Auxiliary PO (Variants) that are providing the necessary consumption materials (see the red/white “+” symbol in above figure 5).

The more PO Variants (Alternatives) are provided to high level planning, the better the flexibility is. For instance, a Due Date Quoting application can select from the Pool of alternative PO Variants according to its optimization criteria increasing its degree of freedom and therefore finding better solutions. However, one should be careful that certain amount for PO Variants becomes hard to handle for both systems and users, so a reasonable compromise must be found.

Dynamic Order Dressing – Alternative Intermediate Materials

There are even more solutions possible for Planning if considering alternative intermediate material dimensions for Allocation or Caster Scheduling. Depending on the plant setup

- One could cast alternative slab dimensions that can (still) be transformed to the requested Finish Good. This might come at a cost on the one hand, but allow you to better plan casting sequences on the other hand.
- The plant is (partially or exclusively) purchasing intermediate materials (e.g. Slabs, Billets or Hot Rolled Coils) as Input materials in certain standardized formats from various Vendors and you want to make the most out of the available stocks.
- The plant has considerable amount of free stock due to quality issues or overproduction

For all those cases the Dynamic Order Dressing provides the feasible and preferred alternative Intermediate Material Demands throughout each PO Variant's route.

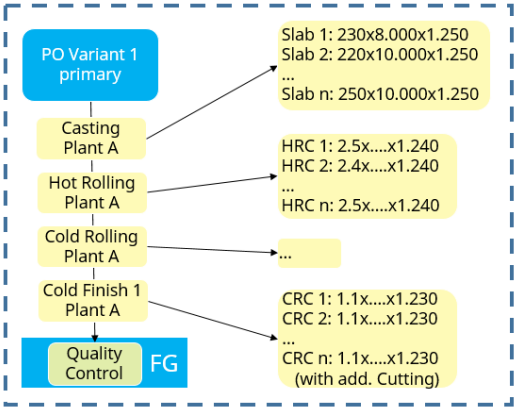

Figure 6: Alternative material demands for PO Variant 1

Above figure 6 illustrates this for one PO Variant (others would be analogue), providing the Material dimensions, yield and cutting factors throughout the routing.

Thereby Dynamic Order Dressing is branching out the Material Demand Variants whenever it encounters alternative dimensions or variable cutting factors during the calculation of transformations at various PO steps (e.g. one could use different thickness, cut 1-4 times). The definitions can use discrete figures, which is quite typical if a plant runs standardized sizes, but could as well use mathematical formulas. Material Demand Variants are filtered by suitable criteria to limit the amount and ultimately flexible ranking criteria will determine the best Material Demand Variant (meaning selecting the layout of the starting material and the subsequent transformations, cutting factors, yield etc.).

So while the optimal (= best ranked) Material Demand Variant is automatically used within each PO Variant, the alternative Material Demand Variants can either be

- Provided to Allocation Application to have more options.
- Branch out the PO Variants (so both Routings times Material Demand Variants lead to PO Variants) to deliver even more options to High Level Planning (DDQ).

Dynamic Order Dressing – Forward Dressing for alternative materials

If the actual materials on stock do not match the selected PO Variants primary Material Demand layout (e.g. there are no slabs with thickness 220 mm on stock), then Alternative Material Demands can be used in order to keep the due date (e.g. purchased or leftover slabs with 250 mm thickness are found).
However starting the Production Order from a different Plan material might require adjustments in regards to dimensions / cutting factors as well as Primary Data Inputs (PDI) and Inspection Plans (laboratory tests and visual inspections) for various lines. For example if allocating a much bigger slab, you need to perform additional cutting downstream if the customer expects smaller strips to be delivered.

This could be solved by generating PO Variants for all combinations of Routing alternatives and Material Demand Variants upfront (as described in the last paragraph), or by implementing a reactive solution using Forward Dressing as described hereinafter (concept see below figure 7).
Forward Dressing generates a material specific Production Order (MAT PO) for a given non-primary Material, according to an alternative Material Demand Variant or even “any” material that does not directly fit to the Master PO. Hereby the MAT PO is calculated upon request and linked to its parent object, the Master PO, for balancing reasons.

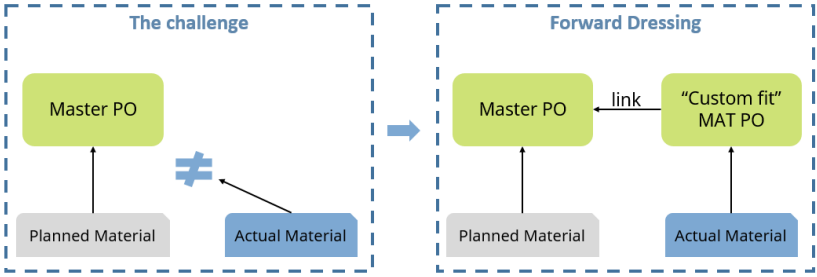

Figure 7: Forward Dressing Concept

In the following, the Forward Dressing process is described as depicted in below figure 8.

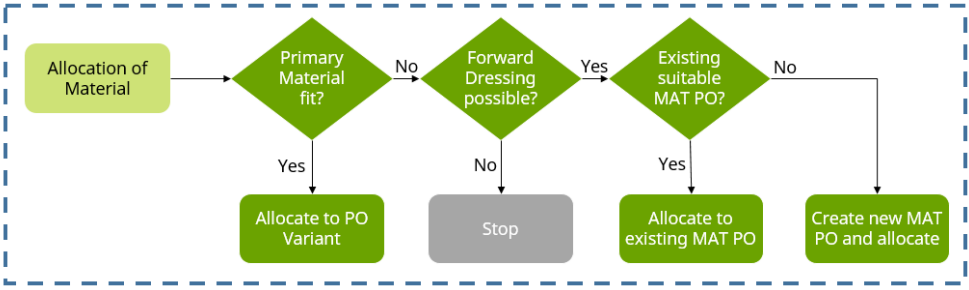

Figure 8: Forward Dressing process

If the material to be allocated matches the primary Material Demand Variant, it is simply allocated to the PO Variant. However if it does not match, then Forward Dressing is triggered. Here another rule set is checked to avoid impossible MAT PO's (e.g. one cannot allocate a Billet instead of Slab, the Grade must match). Finally, it is checked if a suitable MAT PO already exists, that could be re-used (e.g. Slab must have the same thickness +/- some tolerance). If there is no suitable MAT PO available, a new one will be requested.

The Dynamic Order Dressing is calculating the MAT PO from scratch based on the known SOI data and the additional imposed characteristics coming with the Forward Dressing Request (at least the material dimensions, possibly other material characteristics). Therefore in principal the same configuration is used, as for the initial PO calculation, however whenever needed additional decisions can be branched out (e.g. you fix the starting material instead of dynamically determining it, but the downstream cutting will be calculated with the existing transformation rules). Once the new MAT PO is generated including all required target data (routing, material demand, PDI, inspection plan, etc.), the material is allocated to it.

Forward Dressing for alternative materials significantly reduces the amount of free stock, by creating custom fit MAT PO's for otherwise "unusable" materials.

Dynamic Order Dressing – Forward Dressing for quality deviations

When Laboratory tests (e.g. Tensile), visual inspections (e.g. ultrasonic) or Predictive Indicators (predictive models considering production and quality data) reach some borderline range or hard limits, Forward Dressing could be triggered to create an adaptive Material specific PO to ensure the final quality targets are met.

In the end, this is a very similar workflow as described in previous section mainly with a different trigger (Quality Deviation vs. Allocation/Reservation), again resulting in a custom fit MAT PO. For instance if the Hot Rolling exit temperature was on the lower side (but still within accepted tolerance), a predictive Model could trigger Forward Dressing that generates a MAT PO with adjusted downstream Annealing cycle to still meet the quality specification of the SOI's Finished Good.

Forward Dressing for quality deviations allows to react very early and address any kind of quality issues, avoiding deallocations, downgrading or worse in many cases.

Conclusion

The advanced features, the underlying concepts and terminology of the Dynamic Order Dressing were introduced.
It was presented how these features support the Planning world by providing the best possible order book as vital input for its optimization runs (providing all PO Variants as required) and providing more options for Allocation (both upfront Material Demand Variants and reactively by Forward Dressing a custom fit MAT PO). Finally, it was shown how it helps reducing the need of bad Quality operations (again by Forward Dressing a custom fit MAT PO as early as possible).

It is important to stress that with the Dynamic Order Dressing one is building a central, consistent, multi-purpose knowledge base which simplifies the maintenance of complex configurations and provides one central, consistent source of truth. At runtime, the engine of the Dynamic Order Dressing dynamically calculates any kind of request using the information from the central knowledge base.