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A Simulation Framework for the Evaluation of Production Planning and Order Management Strategies in the Sawmilling Industry

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Abstract: Raw material heterogeneity, complex transformation processes, and divergent product flows make sawmilling operations difficult to manage. Most north-American lumber sawmills apply a make-to-stock production strategy, some accepting/refusing orders according to available-to-promise (ATP) quantities, while a few uses more advanced approaches. This article introduces a simulation framework allowing comparing and evaluating different production planning strategies as well as order management strategies. A basic ERP system is also integrated into the framework (inventory management, lumber production planning algorithms, ATP and CTP calculation, etc). The user can configure the production planning and order management process, and evaluate how they will perform in various market contexts using the discrete event simulation model.

Keywords: Production planning strategies, lumber, order management, simulation

1. INTRODUCTION

Sawmilling is a process difficult to manage. Raw material (log) comes from the forests and shows a great diversity in terms of wood quality, diameter, length, etc. The sawmill must take into account this heterogeneity while trying to maximize produced value and/or meet customer expectations. Satisfying demand is difficult for the following reasons. First, sawing generates many products at the same time (i.e., divergent process with co-production), which cannot be avoided (Wery et al. 2012). Many researchers have proposed models to optimize lumber production. However, companies do not necessarily know the best way to integrate these optimization models within their management processes.

This paper describes a simulation framework developed to compare and evaluate different planning and order management strategies. Each strategy is defined by: the production planning models used, the size of the planning horizon, the re-planning frequency, and the order acceptation criteria (which can be based on stock levels, ATP, CTP, etc).

These strategies can be evaluated for different market conditions in order to answer questions such as: What control strategy should be used for this market? What should be the planning horizon and the planning interval to improve the financial performance of the company? If reducing the lead-time was possible, what would be the rate of acceptance for new orders? Should we re-schedule more often when business activities are increased?

This paper is organized as follows: Section 2 presents a review of existing tools used to support the decision-making process for different stages of a lumber production system. Section 3 introduces the simulation framework. Section 4 presents a case study used to demonstrate how the framework can be used to compare different strategies. Very basic strategies are used in order to verify the model. In Section 5, results are presented and analysed.

2. BACKGROUND

Lumber production is a three phase manufacturing process. As described by Gaudreault et al. (2010), it involves three facilities. First, the sawing unit is responsbile for sawing logs into green rough lumber according to different cutting patterns. At this step, produced lumber vary in quality (grade), length, and dimension. Then, the lumber must be dried using a kiln unit in order to reduce the moisture content. This step is necessary to use the lumber in construction industry (Wery et al. 2014). According to Yan et al. (2001), drying operation is crucial to ensure quality (by reducing biological damage, by increasing dimensional stability) while reducing transportation cost. The final step is conducted by the planing unit to obtain the desired surface and thickness.

Many optimization models have been developed to support decision making process in the lumber industry. They lead to optimal or near-optimal solutions. The aim of this type of optimization is often to maximize value or minimize costs.

Marier (2011) and Marier et al. (2014) proposed a tactical MIP model integrating production (sawing, drying, finishing), sales, and distribution. A Sales and Operation Planning (S&OP) approach is used to correlate sales, marketing, procurement, production, and finance, so as to create an annual plan that takes into consideration different product families. A similar tactical planning model was proposed by Singer et al. (2007) for the Chilean sawmilling industry.

At the operational level, Gaudreault et al. (2010) proposed three MIP models that can be used to plan/schedule sawing,

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drying, and wood finishing (planing) operations. The objective function allows maximizing production value and/or minimizing orders lateness. A basic coordination mechanism (heuristic) is provided to synchronize those plans. Improved coordination mechanisms are proposed in Gaudreault et al. (2009) and Gaudreault et al. (2012). A stochastic version of the sawing operations planning was developed by Kazemi-Zanjani et al. (2013). An improved version of the drying model was also proposed in Gaudreault et al. (2011).

Even though the previous optimization models show many benefits, they still involve many challenging issues such as how they should best be used by a specific company evolving in a specific market context. Each company/production unit should put in place an operation management system integrating (1) optimization models and algorithms; (2) business processes and policies.

To deal with this issue, discrete-event simulation can be used to test different scenarios and show how the different changes in the operating environment will impact the performance of the organization. Discrete-event simulation can be used in such context. For example, El Haouzi et al. (2008) used discrete-event simulation to compare different manufacturing system in a company implementing Demand Flow Technology (Costanza J. 1996). In Abdel-Malek et al (2005), the authors compared different supply chain outsourcing strategies. The key performance indicators used were the inventory levels and the total cost.

3. SIMULATION FRAMEWORK

The framework presented here allows comparing and evaluating different planning and orders management strategies. Each strategy is defined by: the production planning models used, the size of the planning horizon, the re-planning frequency, and the order acceptation criteria (which can be based on stock levels, ATP, CTP, etc.).

These strategies can be evaluated for different market conditions (order arrival rate per product, order size, demand lead time, etc.)

A discrete event simulation model is developed using SIMIO. The user can therefore define scenarios visually (i.e. configure its operations management framework and market conditions). The simulation model is also connected to a basic ERP system (inventory management, lumber production, planning algorithms, ATP and CTP calculation, etc) we developed.

3.1- Simulation framework description

A conceptual representation of the framework is provided in Figure 1.

For each product, orders are generated in (1) according to a given arrival rate. Following Ben Ali et al. (2014), orders in the lumber industry typically follow a Poisson distribution. Other distributions are provided to model the size of the order and the demand lead-time. This parameter corresponds to the time between the order arrival and the delivery date D (Tony Arnold et al. 2010).

Each order can be either accepted or rejected (2) according to a given policy. If the order is rejected, it leaves the system. If it is accepted, it waits until delivery date and material availability (3). The order is then shipped (4).

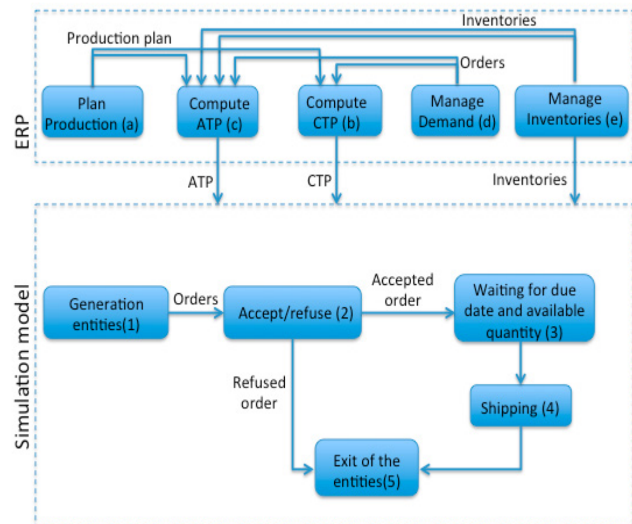

Figure 1: Conceptual representation of the framework

The ERP system is in charge of the planning production (a) using a model from Marier et al. (2014). The ERP also offers services for computing volumes that are available to promise (ATP) (b) and capable to promise (CTP) (c), while managing a list of accepted orders (d) and inventories (e).

The simulation model "calls" the ERP each time a planning is needed, a new order is accepted, or when ATP, CTP or inventory information is needed.

Parameters of the model specify the simulation horizon, the planning horizon, and the re-planning frequency. The user also needs to specify which policy should be used to accept/refuse an order. The order can be accepted based on current stocks, ATP, or CTP.

3.2- Order acceptation policies

Stock: a tentative order of size Q is accepted if current inventory I minus the sum of commitments (accepted orders not delivered yet) is greater than or equal to Q.

ATP: an order is accepted if

Q ≤ Minimum foreseen stock after order due date

$$Q \leq I + \sum_{t=now}^{D-1} (P_t - E_t) - \max_{D \leq t \leq T} \left\{ \sum_{k=D}^{t} (E_k - P_k) \right\}$$

Where D is the order due date, T is the simulation horizon and I is the current inventory, Pt the production at period t and Et the commitment at period t.

CTP: When processing an order, a tentative production plan is computed in order to check if we can satisfy the new order without compromising the previously accepted orders.