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Optimization of Production Schedule Using Advanced Scheduling Tools for Green Production

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Abstract: Significant number of producers and manufacturers are realizing substantial financial and environmental benefits from sustainable/ greener business practices. Sustainable production and manufacturing are the creation of manufactured products through economically-sound processes that minimize negative environmental impacts while conserving energy and natural resources. Sustainable manufacturing also enhances employee, community, and product safety. The aim of the paper is to provide the right information about using scheduling tools such as Advanced Planning and Scheduling tools to improve lead times, optimize constraints by this reduce waste time and lower emissions produced by producing the waste. This paper deals with problematic of production optimization and its impact on production efficiency.

Keywords: Scheduling, Green production, manufacturing; APS, Advanced Planning, Scheduling

1. Introduction

Today, the question about the reduction of emissions is more important than ever before. Pressure on manufacturers is rising daily not only to reduce emissions but also to be able to produce more efficient and lower costs.

Green production might be defined as "concerned with or supporting environmentalism and tending to preserve environmental quality (as by being recyclable, biodegradable or non-polluting)". This definition alone is broad, but when applied to manufacturing the general idea of green manufacturing is a process or system which has a minimal, non-existent, or negative impact on the environment. A definition adapted from one proposed by the U.S. Department of Commerce has sustainable manufacturing as "the creation of manufacturing products that use materials and processes that minimize negative environmental impacts, conserve energy and natural resources, are safe for employees, communities, and consumers and are economically sound".

Advanced Planning and Scheduling (APS) systems are either add-ons or direct integral components of the Enterprise Resource Planning (ERP) systems. The key aims of APS system are the problem from finite-capacity scheduling at the shop floor level to constraint-based planning. The APS systems were established to predict the future production schedule by exact mathematical optimization techniques and heuristics. However, APS systems lacked a part of flexibility such as the control strategies for sequencing being permanently defined. The current APS systems cannot provide the optimal configuration of the control strategy based on the current situation. In addition, a solution of the possible combinations of control strategies regarding the dependencies of individual jobs and machines is too complex for humans.

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2. How we can define Green production

There is strong pressure to distinct between the definition of green manufacturing and lean manufacturing which some use interchangeably, even though the two systems have different aims. Lean manufacturing is centred around creating more value for the customer (internal/external) with less work – higher productivity. Toyota was a key player in the development of lean manufacturing and in the process of doing so Toyota targeted the reduction of seven wastes as part of the Toyota Production System:

- *Overproduction (including early production)*
- *Transportation*
- *Inventory*
- *Motion*
- *Defects*
- *Over-processing*
- *Waiting*

Now, several of these wastes defined by the Toyota production system shall be related to the desire to minimize the environmental impact of a process. **For example, if waiting time were decreased one may argue that resources such as factory lighting and air conditioning or heating would be used more efficiently.** Many production machines and production lines consume a lot of energy, even when they are not producing any product or processing or when those machines are set up for another product. So, an idle time designed to allow smooth flow of product at other machines wastes energy and resources.

Lean manufacturing might be defined as a practice that attempts to identify and evaluate the use of resources and processes for anything other than adding value for the end of the customer. It then defines these uses as constraints and tries to eliminate them or push them. Further to this, it is understood that there are several approaches to "lean manufacturing". The first approach can be defined as the elimination of waste and the tools that assist in uncovering waste in the process and system and getting rid of it. A second approach is more aligned with the Toyota Production System, focused on the "smoothness" of production and constructing a process with the capability to produce the required results by designing out process with the capability to produce the required results by designing out process inconsistency.

Sustainability of Green production

Is there any difference between green manufacturing and sustainable manufacturing? It is crucial to define sustainable and sustainability.

Sustainable development has been defined by the World Commission on Environment and Development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs. This definition includes within it two key concepts:

1. The concept of "needs" in particular the essential needs of the world´s poor, to which overriding priority should be given.

2. The idea of limitations imposed by the state of technology and social organization on the environment´s ability to meet present and future needs.

Barriers to Green Manufacturing

A manufacturing system involves a wide range of parties including material and other tier suppliers, other producers, retailers, consumers, and many more. As the stakeholders are becoming more aware of the values of green sustainable manufacturing in practice, the manufacturing industry is highly motivated to implement those strategies to reduce the environmental impact and moreover, to improve the economic performance of its manufacturing processes, manufacturing operations.

Motivations for Green Sustainable Manufacturing

There are several green drivers in effect motivating any manufacturing industry towards green sustainable manufacturing practices. The motivation factors can be summarized in the three categories of regulatory pressure, economic incentives, and competitive advantages. Specific examples of these motivations include the following:

- *Pressure from Government - Regulations, Penalties and Tax benefits,*
- *Interest in Efficiency/ Reduced Cost of Ownership,*
- *Scarcity of Resources/ Risk,*
- *Continuous Improvement,*
- *Pressure from Society/ Consumers/ Customers and other competitors,*
- *Desire to Maintain Market Leadership,*
- *Insure Control of Supply Chain Effect (what´s happening outside of your facility),*
- *Several of these categories will be looked at in more detail.*

Advanced Planning and Scheduling (APS) can be defined also as manufacturing management systems that optimally allocate production capacity to meet demand. Advanced planning and scheduling systems are especially well suited to environments where simpler planning methods cannot adequately address complex problems between competing priorities and where response time against production deviation is crucial or where complexity is too high.

Features of Scheduling

Production scheduling is intrinsically very difficult due to the high number of different schedules that are possible with even a few numbers of items to be produced and it is one of the most important processes for every production company, but it is very different from company to company. All scheduling processes share several common features. Schedules are available with Gannt Chart view to see Fig.1.

» *They are complex decisions, as they involve developing detailed plans for assigning tasks to resources over time. Although this may vary greatly from one company to another, there is a universal trend on increasing the sophistication of the products and on their customization, which in turn affects to the complexity of the manufacturing process.*

» *Scheduling decisions are short time interval decisions to be taken over and over. The average lifetime of a schedule is very short, and indeed many authors refer to a continuous scheduling decision process. Here we mean that what is repeated is the decision process, which is different from stating that the outcome of a single decision is put into practice rhythmically again (cyclic scheduling).*

» *Despite being a short-time decision, scheduling is relevant for companies' bottom line, as it determines the lead times and the cost of the products, which in the long run affects the service level of the company as well as its ability to compete both in manufacturing costs and on delivery times.*

» *As a decision process at the core of the operations of a manufacturing company, the constraints and objectives affecting scheduling are extremely company-specific. The nature and usage of the resources in a plant producing chemical commodities have little in common with manufacturing ball bearers or assembly of highly customized electronic devices.*

» *Finally, scheduling decisions are as we already discussed relatively structured decisions, at least as compared to other decision problems within the company. Its operational nature makes scheduling require fairly well-defined data, constraints, and objectives.*

Machine utilization view – Scheduling software allows viewing machine utilization while building schedule. It gives production employees a view how effective his/her plans are during the time period. See Fig. 2 machine utilization view.

Scheduling rules – Scripting

While building schedule, allows to user to build a schedule according to some specific scripted rules to optimize the desired outcome. Scripting also allows users to create their own custom functionality as a sequence of actions, and for that script to be executed in response to an event. Scheduling software select Scheduling Rule as provided that facilitates the presentation and execution in the Sequencer of all the APS scheduling rules available. Scheduling rules might be like (see Fig. 3. Selection of APS Rules):

» ***Forward scheduling*** *is planning with the primary objective of completing a task as soon as possible.*

» ***Backward scheduling*** *when businesses make their items at the last possible available period before the due date*

» ***APS Minimize set up*** *– to group product orders to product families and reduce set-up of the machines.*

Scheduling

Each industry is specific by requirements and regulations. For the reason of this paper, I like to focus on examples of Scheduling in the Automotive industry. This might proceed as complicated due to the complexity of the supply chain, where lean and agile manufacturing processes cooperate and integrate, although OEMs and suppliers have different production approaches and pressure on costs. The later focus on customization (make-to-order and configure-to-order) while the former focus on standardization (make-to-stock), thus making collaboration tough and prediction of production result challenge.

» *A.Push – Standardization – Make to Stock*

» *B.Pull – Customization – Make to Order*

The problem with Scheduling is that the delivery date of remotely assembled parts is subject to change and adjustment, therefore companies must schedule based on expected lead-time. Quite often there may be disturbances that make the scheduling not valid anymore, such as delay in material supply, change in customer orders, unexpected manufacturing issues, defects, unplanned resources unavailability (machines, tools, people, etc.) making it very difficult for the subsequent processes to keep adherence to planned delivery time. This is because keeping schedule up to date is a time-consuming task, requiring synchronization of many different data (raw materials stock levels, resources availability, supply date, and order due dates). In case of deviation, such as the ones described above, it is difficult to quickly understand the production scenario and identify the impact on productivity,

Figure 1: Gantt chart view

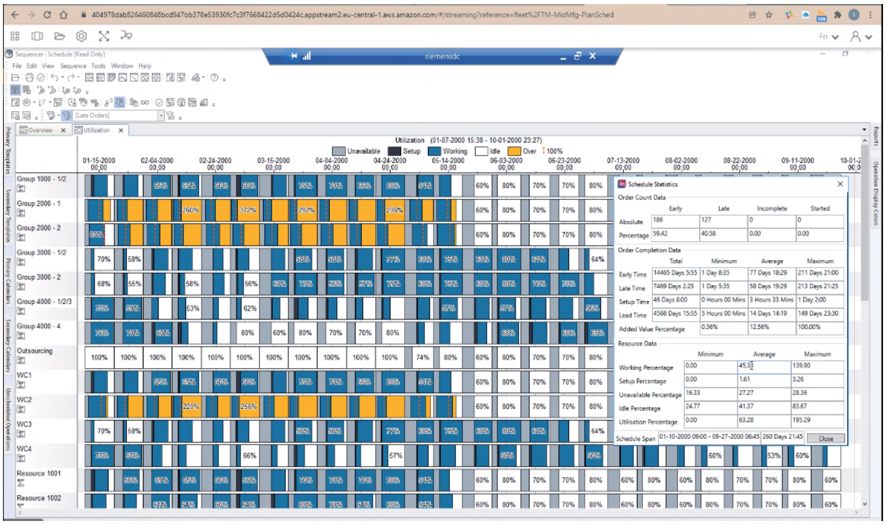

Figure 2: Machine utilization view

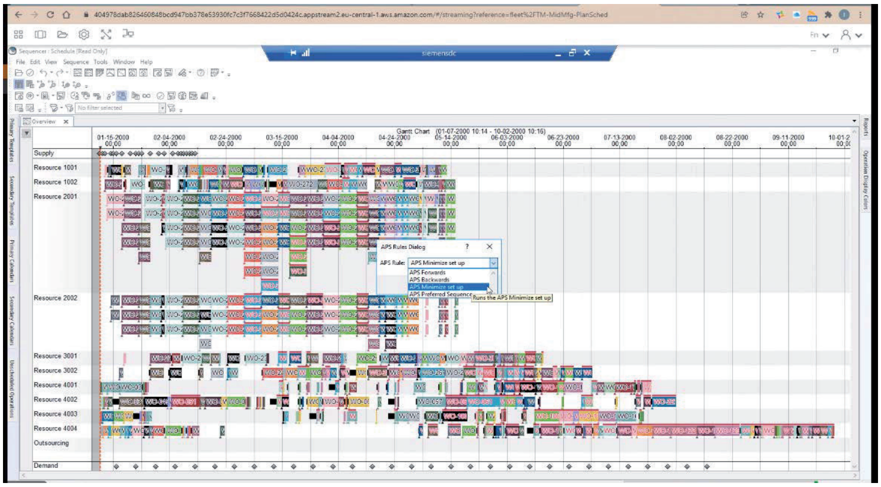

Figure 3: Selection of APS Rules

efficiency, due dates. When more than one option is available, it is also difficult to compare them and evaluate which one performs better (the so-called what-if analysis) In such a situation it is greatly helpful a tool to keep schedules up-to-date, to evaluate and compare possible alternatives aiming to keep the delivery time as promised, or if this is not possible to understand and inform all impacted processes of production scheduling changes. Scheduling is trying to reflect the challenges which automotive sector is facing and adapt on top of it. Advanced planning and Scheduling systems are working on base constraints models, which define conditions how the schedule is built mathematically.

Challenges of the Automotive sector:

- *Need to adapt faster than ever*
- *Important to focus on capacity management and efficient utilization of resources*
- *Importance to efficiently manage supply chain*
- *Importance for better cross-team collaboration*
- *Output management on a day-to-day basis*
- *Number of product variations is raising*
- *Market differentiation from country to country*

Constrains overview for typical Automotive Tier 1 supplier

Supply => Raw Materials) => ***Turning*** (Changeover, dedicated resources, operators) => ***Milling*** (Changeover, dedicated resources, operators, Tool constrains) => ***Gearing*** (Changeover, dedicated resources, operators) => ***Washing*** (Changeover, dedicated resources Product, type preference, operators) => ***Finished Goods*** => ***Demand***

Comparing different types of schedule building and their influence on overall lead time

Overall lead time is an important parameter while building scheduling in Automotive. It not only influences energy consumption but also reflects how effective/lean production is. For the reason of this paper, we are comparing Simple Forward scheduling with scheduling which minimizes setup times of machines. The key parameter to follow is the overall lead time of production. Shorter lead time means less product storage which is reflected to less consumed energy for cooling and heating or overall warehousing.

The average lead time for Forward scheduling (see Fig. 4.) is approximately 14 days compared to Average lead time for scheduling rule – minimize setup (see Fig. 5) is approximately 8 days.

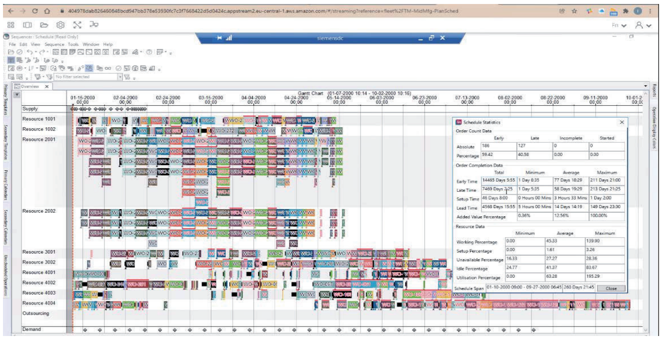

Figure 4: Forward scheduling

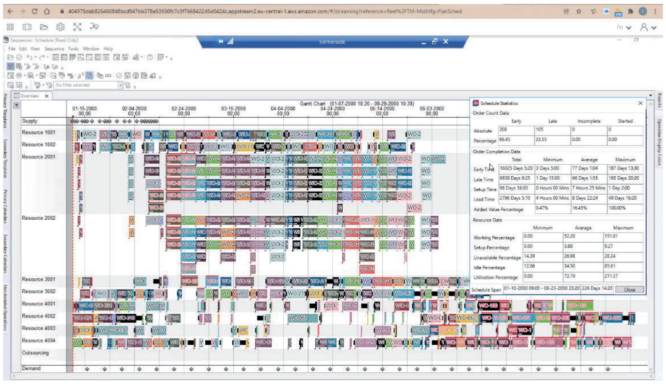

Figure 5: Scheduling minimize setup

3.Conclusion

The importance of effective production of products not only in Automotive is one of the major game changers and differentiators of the leaders compared to the rest of the companies in the sector. Advanced Planning and Scheduling tools might help companies to achieve their reduction of emissions or more effective production alongside other tools which companies need to take. Shorter lead time reflects not only in warehousing costs of not finished products but also while the company is scheduling to minimize setup it is increasing machine and resource utilization. This can be understood as machine/resource is in more in added value activities compared to the time when it is setting up and waiting idle. Many of the production machines and production lines consume energy even while waiting idle so this also reflects to overall energy consumption and how much of this energy was consumed to add value for the paying customer. While companies are looking for tools to reduce emission production, Advanced planning and scheduling tools shall be not only selection of companies to achieve it. These tools should be just part of the overall story which company needs to take to be more efficient.

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