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Advanced Planning and Scheduling (APS)

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ABSTRACT

Planning and scheduling is a topic which concerns and affects many manufacturing companies. It optimizes the schedule to meet customer service objectives, operational efficiencies, cost containment and profit objectives. It also provides a safe planning environment using "what if" as well as ability to "undo" a schedule change. APS is "bolted-on" to ERP (Enterprise Resource Planning) and we strongly believe that most of the ERP systems used today do not have the tools and technology required to manage finite capacities, the good news is that in most cases these capabilities can be easily added to any ERP system. Most of the ERP systems were designed to address the needs of the make to stock (MTS) manufacturer but many businesses now moving to a make to order (MTO). In this paper we will discuss the challenges faced by the planners and managers, Limitations of ERP, Optimization of FMEA (Failure mode effect analysis), and Total Quality Management (TQM).

***Index Terms**—APS (Advanced Planning and Scheduling), ERP (Enterprise Resourcing Planning), FMEA (Failure Mode Effect Analysis), Total Quality Management (Total Quality).*

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I. INTRODUCTION

We use the terms scheduling and APS interchangeably. APS is an acronym for Advanced Planning and Scheduling and in most cases it is just a fancy name given to finite scheduling software. We will going to go deeper in scheduling as a whole. [2]

I will argue that the needs of the make-to-order manufacturer are very different and that generally there is a growing need to be more agile and lean. This can only happen if production planning and scheduling systems can handle cause and effect. Without this capability a company will never have the information needed to make smart decisions about their capacity.

A repetitive theme of this paper is the observation that by stripping away the buffers of excess time and inventory we start to expose some major limitations of ERP systems. Put simply, make-to-order manufacturers are in the business of managing and selling their capacity, which means that they need a better set of tools than most ERP vendors are providing them today. [1]

II. CHALLENGES OF PLANNERS AND MANAGERS

2.1 Changes

In our natural and human systems more or less rapid changes are always occurring. Many of these changes are triggered by human activities. First, planners and managers have to consider these possible changes in their decision-making. The plans have to be flexible. Second, planners and managers have to perceive actual changes and adapt their plans and management accordingly.

2.2Complexity

The interdependence of natural systems and the ramifications of interactions of human activity with the natural environment are complex. Planners and managers have to understand the different components, processes, and their interactions very well to develop sustainable management and development strategies for the specific system.

2.3 Uncertainty

Due to the complexity and changes, planners and managers do not have complete information about all factors influencing the decision. Nevertheless, they have to make decisions despite their lack of information about the ecosystem for which their decisions have consequences.

A. *Conflicts*

Different, and often conflicting, values and perspectives are usually involved in resource allocation and use decision. Planners and managers are often faced with conflict situations and have to recognize and mediate between the conflicting sides. This is associated with the intergenerational and intergenerational equity implied in the term sustainability.[4]

III. WHY SCHEDULING IS so CRITICAL?

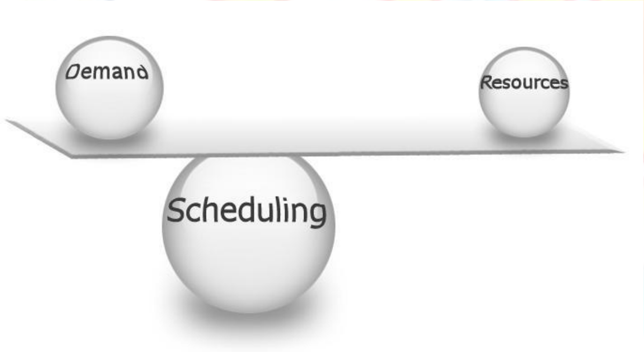

Figure 3.1

As the diagram above shows, scheduling is the process of balancing demand for products with a company's available resources for the purpose of creating a valid action plan.

Demand would include customer orders, stock replenishment orders and samples, while Resources includes machines, operators, tooling, and inventories of raw materials, sub parts, and finished goods.

As I mentioned earlier in the paper, we use the terms scheduling and APS interchangeably. APS is an acronym for Advanced Planning and Scheduling and in most cases it is just a fancy name given to finite scheduling software.

I sincerely believe that scheduling is the brain center that drives the operations side of a manufacturing company. As such the schedule should be able to absorb the constant barrage of changes that impact a business and quickly create a new action plan. This plan should reflect the strategic direction of a business.

By the perception we get from this, does **not lead as to say that this process should be completely automated but we should be able to reschedule your plant in a few seconds or at worst a few minutes**. To be useful, your scheduling system must be able to realistically model real world constraints so that it can provide management with the information needed to make important decisions.

One way to look at scheduling is as a way to answer the question, "What should I make next?" This is actually a critical question because every minute a manufacturer spends making the wrong stuff not only increases costs, it takes away from his ability to deliver what the clients actually need.

The schedulers are very powerful. Without an APS system the scheduler gets and uses their power by putting out fires and they often have absolute control over who gets priority. Managers and executives soon learn that they must bow to this reality or face the consequences. Those schedulers who are unable to give up their power trip must be replaced sooner or later. My strong recommendation is that they be replaced sooner.

Of course the top-notch scheduler, driven by the need to improve, is thrilled to have a new set of tools.

3.1 Gantt chart use:

One great way to view a schedule is in the form of a Gantt chart (see below). The Gantt chart shows how each of the resources (machines or subcontractors) is loaded over a selected time-period. Believe it or not, **a good scheduling system will create a complex schedule within a few seconds or minutes.** [1]

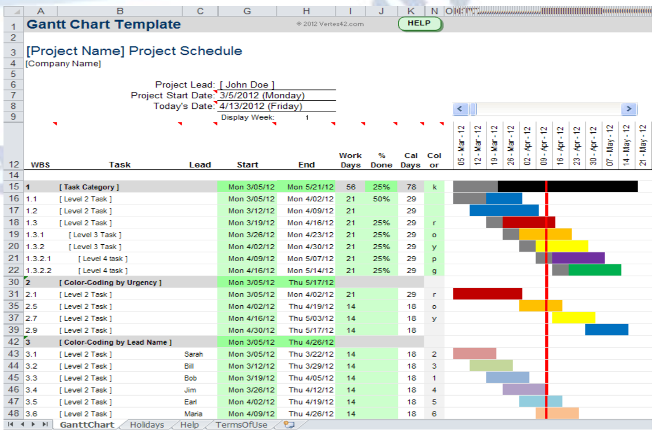

Figure 3.2 Gantt chart

IV. BASIC SCHEDULING FUNTIONALITY

1. The ability to schedule more accurately at the machine level as opposed to the work center level and to assign different shifts and run speeds for each machine.
2. The ability to schedule each machine finitely or infinitely.
3. The ability to schedule using multiple constraints (such as tooling and operators).
4. The ability to calculate sequence dependent setup times.
5. The ability to schedule precisely (minutes or seconds) as opposed to time buckets (usually days or weeks).
6. The ability to integrate easily with other systems like ERP and Shop Floor Data Collection (SFDC).
7. The ability to sequence orders based on due date, priority or some other attribute.
8. The ability to schedule quickly (minutes or seconds) and maintain a real-time view of the schedule.PR
9. The ability to easily make changes such as adding new orders, changing priorities, adding machine downtimes or completing operations.
10. The ability to synchronize the schedule with material constraints. [1]

V. THE POWER OF SEQUENCING

Explaining the wonders of sequencing is one of the fun things I get to do in my seminars. I have described the basics of a good scheduling system. Now I need to prove that there is a whole new world out there to explore. That world is the world of sequencing.

A simple way to understand sequencing is to think of two cars going down a single lane highway. One can go at 120 mph and the other can go at 30 mph. If we assume that they can't overtake each other how long does it take them to drive 30 miles? Of course the answer is easy, the fast car can drive 30 miles in 15 minutes, or can it? If it is behind the slow car then it will take the same time as the slow car, which is 1 hour.

When it comes to sequencing

$1 + 2 + 3 \neq 3 + 2 + 1$

This is one of the reasons that scheduling in buckets doesn't work.

The ability to manipulate the way that operations are sequenced at a machine not only impacts setup times, it impacts on-time deliveries and work in progress (WIP).

The following is a simplistic example that highlights how a simple change in the way orders are sequenced can have a significant impact on a manufacturer' ability to deliver those orders on time.

In this example, a manufacturer has three machines -- Machine A, Machine B, and Machine C. Assume that the plant has one Eight-hour shift and that it is open seven days per week.

This company manufactures three products with routings as shown below.

Product X	Operation	Machine	Rate
	10	Machine A	24 Hrs.
	20	Machine B	16 Hrs.
	30	Machine C	8 Hrs.
Product Y	Operation	Machine	Rate
	10	Machine A	8 Hrs.
	20	Machine B	8 Hrs.
	30	Machine C	8 Hrs.
Product Z	Operation	Machine	Rate
	10	Machine A	16 Hrs.
	20	Machine B	8 Hrs.
	30	Machine C	24 Hrs.

Table 5.1

For the sake of simplicity, assume that this company has no other orders in the pipeline and that it gets an order for each of these three products.

1) What date can each order be promised?
2) What date can all 3 orders be promised?

Scenario 1:

Order 1 Product X
Order 2 Product Y
Order 3 Product Z

Figure 5.1

In scenario 1 the orders are sequenced X then Y then Z.

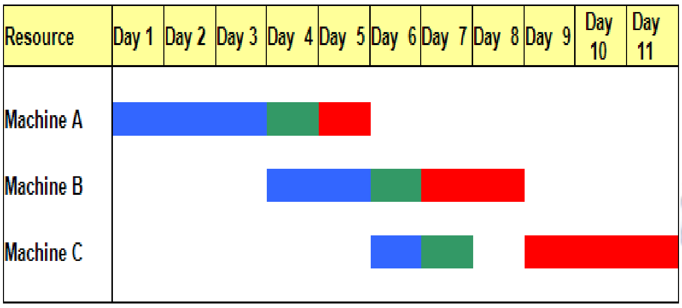

Figure 5.2

The Gantt chart above shows that X can be completed on day 6, Y can be completed on day 7 and Z can be completed on day 11.

Scenario 2:

Order 1 Product Z
Order 2 Product Y
Order 3 Product X

Figure 5.3

In scenario 2 the sequence of the orders is changed to Z then Y then X

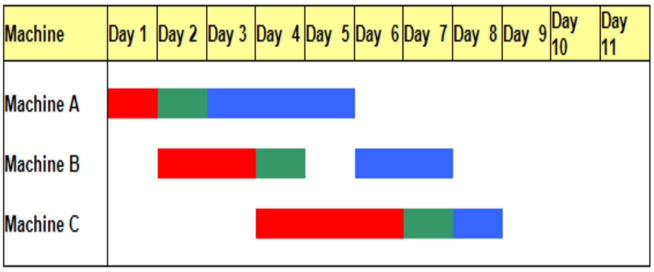

Figure 5.4

Now the Gantt chart shows that this small change has consequences that would be very difficult to anticipate without an APS system. X can now be completed on day 8, Y can now be completed on day 7 and Z can now be completed on day 6.

This example shows effectively that the time it takes to deliver all three orders has been reduced by three days or 27% and simply by changing the sequence of events.

The purpose of this exercise is to demonstrate that the ability to manipulate the sequencing of orders and operations can have a significant impact on the way a plant performs. APS systems should have a number of advanced sequencing rules and the ability to create new rules to address unique requirements. [1]

VI. FAILURE MODE AND EFFECT ANALYSIS

Customers are placing increasing demands on companies for high quality reliable products. The increasing capabilities and functionality of many products are making it more difficult for manufactures to maintain quality and reliability

Failure modes and effects analysis (FMEA) is a steps-by-step approach for identifying all possible failures in a design, a manufacturing or assembly process or a product or service. Failures are any errors or defects, especially once the effect the customer and can be potential or actual. “Effects Analysis” refers to studying the consequences of those failures. Begun in the 1940 by the US military, FMEA was further developed by the aerospace and automobile industry several industries maintain formal FMEA

FMEA is a methodology for analysis potential reliability problems early in development cycle where it is easier to take action to overcome reissues, thereby enhancing reliability through design. FMEA is use to identify potential failures mode, determining their effects on the operation on the product and identifying action to mitigate the failures.

A. *When to use FMEA?*

- When a process, product or services is being design or redesign after quality function development.
- When a existing process, product or services is being applied in a new way.
- Before developing control plans for a new or modified process.
- **When improvement goals are planned for an existing process product and services**.
- **When analysis failures of an existing process product or services.**
- **Periodically throughout the life of the process product or services.**

B. *Benefits of FMEA*

- Improve products/process reliability and quality.
- Increase customer satisfaction.
- **Early identification and elimination of potential product/process failure mode**.

- Prioritize product/process deficiencies
- Capture engineering and organization knowledge
- Emphasizes the problem presentations.
- Document risk and action taken to reduce risk.
- Provide focus for improve testing and development
- Minimizing Late changes and associate cost
- Catalyst for team work and idea exchanges between functions.[5]

VII. PERPOSED SYSTEM

PLANNING ENHANCMENT: PREDICTIVE MAINTENANCE USING IOT (INTERNET OF THINGS)

APS system can be more enhanced by integration of IoT in planning and scheduling procedures, the main agenda of planning and scheduling is to give a predictive maintenance to the whole productive process, application of IoT into APS system increases the optimization of the production process as a whole.

If you are a manufacturer or if you are managing a large install base of equipment, maintaining the equipment optimally is a challenge. You are also likely to take the following approach to maintenance:

- **Calendar-Based Maintenance:** Periodically examining and fixing problems based on a fixed schedule
- **Reactive Maintenance:** Waiting for things to fail and then fix the problem.

Given today's competitive landscape, manufacturers, and asset managers are looking for a better approach:

- **Can I detect equipment failures before they happen, and fix them?**
- **Can I get field data from the equipment and use that in R&D to build a better product?**
- **Can I offer value added services to my customers on top of hardware? For instance, guaranteed equipment uptime for a monthly fee.**

All these concerns can be effectively addressed by integrating Internet of Things (IoT)with your current equipment – IoT is the biggest enabler of Condition Based Monitoring of Industrial Equipment, which is a prerequisite for Predictive Maintenance.

A. What is condition based monitoring?

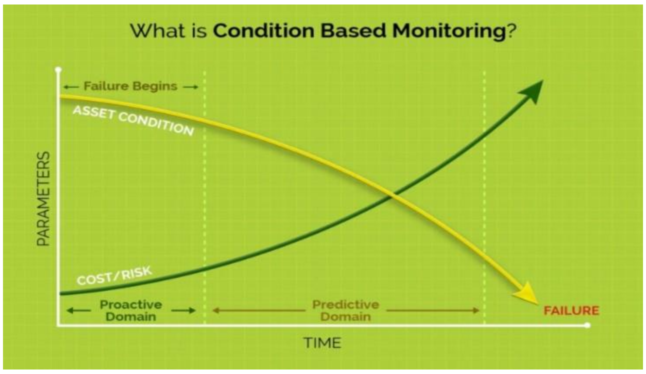

Figure 7.1

Condition Based Monitoring is a process by which the condition of a machine is continuously monitored by looking at pre-defined parameters of the equipment. Doing so enables the tracking of patterns that might indicate equipment failure.

Early failure prediction allows for timely action and prevents a major failure down the line. This ensures longevity and smooth running of the equipment. Condition Monitoring is a critical aspect of Preventive Maintenance; it ensures that equipment is always running or being maintained in a predictable fashion by flagging variance in parameters being monitored. Condition Monitoring also allows you to know when your equipment is nearing end of its life. This allows for the operations team to plan for its gradual replacement.

Once your equipment is connected, you need to start analyzing its parameters for failure. Here are some of the parameters that are commonly monitored and analyzed:

- Vibration: Monitoring the vibration of equipment, usually bearing vibration sensors.
- Temperature: Monitoring the temperature variation.
- Oil Levels: Measuring the variation in oil levels of equipment.

- Acoustics: Using ultrasound to detect changes in sound made by the equipment.
- Motor voltage and current: Monitoring for nuisance corona, destructive corona, arcing and tracking.

7.2 Building up a right failure model

Once your failure parameters are finalized, you would need to establish a failure model for the equipment. This model must be able to distinguish between a normal state and an abnormal state that is a leading indicator of failure.

You are faced with the following choices, once the right parameters are available for analysis

- **What combination of parameter values is indicative of failure.** This form of analysis relies on human intelligence and is far simpler to implement. You need the ability to specify a set of rules or failure conditions. If these are violated, the machine is likely to fail.
- **Have no idea what causes failure.** We need data science and machine learning to figure this out for me. This form of analysis involves using the right algorithms to see patterns in your data.

In most cases, you do know the reasons for failure. You can use classical data analytics and mathematics to build the right model. Machine learning is used in those rare instances where you have no known parameter that is indicative of failure, or if the patterns that cause failure are too complex to discern by standard data analysis. [3]

Figure 7.2 Vibration sensor

APPLICATIONS OF INDUSTRIAL UAVS, APPLYING WIRELESS TECHNOLOGY IN INDUSTRY

Unmanned Aerial Vehicles (UAVs) or drones as commonly referred as have become an inevitable part of technology in defense and homeland security applications. And in this decade with a lot of new sensors and miniaturization of technology, UAVs are finding numerous applications in industrial sectors now days.

Sensors that can be integrated with a UAV

Some powerful sensors which we can integrate with an UAV are listed below:

- LiDARs

LiDARs or Light Detection Radars can be a very powerful tool to carry out surveys and studies. It has enormous applications in mining industry; it can be used for volumetric analysis and a lot more.

- Multispectral and hyper spectral cameras

Multispectral and hyperspectral cameras are used widely for remote sensing applications which can significantly contribute to industrial surveillances using remote sensing technology.

- Radiation probes and gas sensors.

Powerful sensors such as Radiation Probes and Gas Sensors can be fitted on a UAV and these can help find any radiation or gas leaks in the industry and can raise an alarm.

- Thermal Imagers

Thermal imagers or night vision cameras can be used ideally for night applications like perimeter security and surveillance. Photogrammetry camera. Photogrammetry cameras and software can be used for generation of orthomosaics, 3D models and a lot more applications. [2]

Figure 7.3 LiDARs

Figure 7.4 Multispectral and hyper spectral camera

Figure 7.5 Radiation Probe

Figure 7.6 Gas sensors

Figure 7.7 Thermal Imagers

B. *Application of UAV in Industrial sector*

- Pipeline Monitoring

Figure 7.8 Screenshots of pipeline monitoring

- Flare Stack Inspection/Chimneys/Structural Inspections

Figure 7.9 Screenshots of Flare stack Inspection/chimneys/ structural Inspections

- Thermal Inspections using UAV

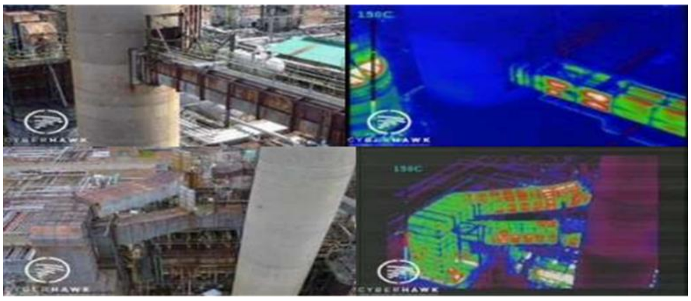

Figure 7.10 Screenshots of Thermal Inspections using UAV

VIII. FUTURE ENHANCEMENT

Integration of IoT in APS system can be used in many ways for getting the required results and the future enhancement of the system will be to construct it such a way it can easily be implemented as an interdisciplinary model, irrespective of the industry type, And try to make it more cost effective in nature.

IX. CONCLUSION

The future of the manufacturing belongs to those companies that are capable to handle change. Manufacturers in the future must consistently process change quicker and smarter than their competitors. And for doing so, the smart way we have now is APS integrated with IoT, which provide a predictive maintenance and condition based maintenance. These type of features lead to improvement in product/process reliability and quality, Increase customer satisfaction and most important early identification and elimination of potential failure modes and minimizes late changes and associated cost. We know that in traditional means for inspection and monitoring large amount of money and skilled labourers are required to inspect critical infrastructures, and it time consuming and hazardous to health, so application of UAV in industry is a monitoring and inspection reduced the cost and there is no need to be in contaminated environment.

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