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Production Planning, Scheduling and Risk Analysis in Manufacturing Operations by Robotic Process Automation*

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Abstract

Practical production planning and scheduling activities rely heavily on timely information from various sources on the production and supply chain. Within this article, the study of current planning, scheduling and risk analysis in the manufacturing sector is carried out in order to explain publicly available challenges and opportunities. The development of a conceptual hybrid real-time decision support system model has been accomplished to address the challenges. The developed model involves advanced and intelligent planning and scheduling techniques and performed by robotic process automation (RPA). RPA anticipates potential risks through the use of time and cost-oriented failure model (tcFMEA) and takes them into account during scheduling. The aim is to reduce overall average production time by enhancing production planning and scheduling in the manufacturing sector.

Keywords: Total cycle time, Decision support system, RPA, Takt time, Planning, Scheduling, Manufacturing operations.

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1. Introduction

The gap between the theoretical and the practical reality of planning and scheduling development in the real world is growing. The gap is exacerbated by the increase of compound structures and other drawbacks in industry 4.0. Therefore most of the newly developed technologies are being evaluated on a small scale and can even only end up being evaluated in the laboratory. Comprehensive production preparation requires precise storage of raw materials, workstations, procedures, equipment and workers involved in the supply chain.

In the context of the manufacturing sector, preparation should also include the production of products most rationally and transparently possible and, during the planning process, it should be possible to define the near-possible bottlenecks in the supply chain and have the best possible means of completing the order on time with titty cost margins.

Production planning is followed by a production schedule which is the most challenging activity in any manufacturing sector, particularly one with a high low-volume mix, which is difficult because production planning requires a highly combinatorial and complex decision-making process[8]. Efficient production planning allows the use of staff, equipment, machinery, etc. Accurate and instant value-added information is highly anticipated in the production schedule for management to take decisions on time, especially in the digital manufacturing sector. In the industry 4.0 era setting, the fixing of several sensors in the production system has rapidly increased. Further real-time output information is stored in the data storage network. The question is how much these timely data are going to support the production schedule on issues of timely delivery of tailored high-quality goods and lower cost of production.

1.1. Problem Statement

The idea is that there is a digital manufacturing cell that consists of more than five machines and has more than ten workers, from which there are several activities that need to be carried out on the machines concerned. Project scheduling is a key issue and the idea behind it is to simplify the existing production scheduling model with the help of robotic processing automation.

The model developed involves the extraction of information from the ERP method, where KPI and output inputs are essential variables for the model. The information obtained from ERP is collected by smart sensors which are mounted across all machines and which are also capable of reading the attached work-piece information which is to be processed in a given machine in the respective series.

The goal is to build a conceptual hybrid real-time decision support system model, Which includes sophisticated and intelligent planning and scheduling techniques and which is implemented through robotic process automation (RPA). The RPA predicts possible risks through the use of failure mode and impact analysis (FMEA) and takes them into account during scheduling. The goal is to reduce the total average production time by improving production planning and scheduling in manufacturing industries.

2. Related Works

2.1. Production planning

Production planning is a dynamic process requiring coordination between several organizational units of every organization. Planning includes what to do when to make it, how much to make it, where to make it, the material required, and the tools needed.

The overall efficiency of the production system depends on the efficient preparation and process design at the shop flow stage. There are three planning horizons in production planning; strategic, intermediate and tactical, but these two horizons cover two areas of interaction with supplier relationships, costs and time markets.

Considering the figure 1 below, the production planning starts from the strategic level as described in section 2.1 and planning is typically caused by real demand or expected demand. Strategic planning is further broken down into incremental planning from quantitative planning, and comprehensive planning can be derived.The preparation of the material specifications is the next step after thorough preparation. The final and challenging stage of the model is planning, which is the focal point of discussion.

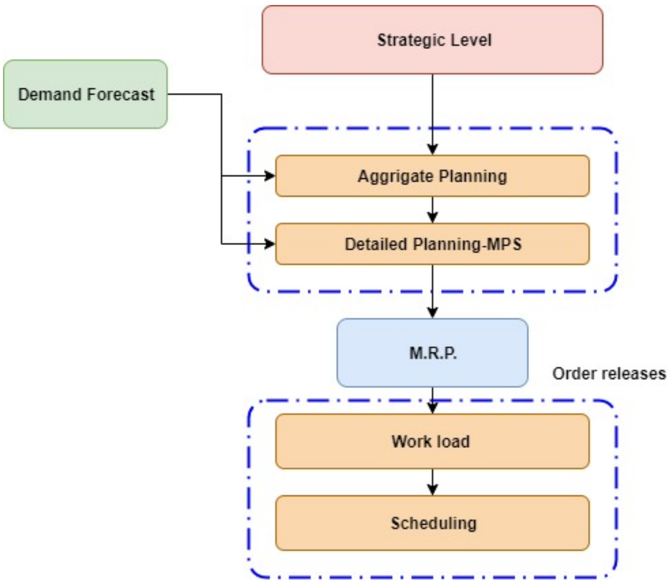

Figure 1: A typical production Planning Approach [8]

2.2. Production Scheduling

Scheduling is defined as the allocation of resources and the sequence of tasks for the production of goods and services. Production scheduling specifies the time each job starts and finishes on each machine. Often scheduling is characterized as an act of prioritizing or organizing activities to meet individual requirements, constraints or objectives[15].

The discovery of innovative production scheduling methods is becoming mandatory in today's digitized output[6]. The Smart Scheduling layer mainly includes advanced models and algorithms for drawing on data collected by sensors. Data-driven approaches and advanced decision-making architecture can be used for smart scheduling, for example, in order to achieve real-time, efficient scheduling and execution of distributed smart models using hierarchical integrated architecture[16].

Real-time decision-making is the delivery of contextual and synchronized workflow information to any system anywhere at any time so that decisions can be taken. In the sense of production planning, smart sensors are necessary when it comes to real-time decision-making. Most manufacturing plants continue to use different types of production Scheduling approaches to improve efficiency and minimize production costs[6, 9].

Production planning in many manufacturing industries has been widely used in recent years. It continues to be more prevalent in the modern era of cyber-physical systems or the digitalized manufacturing environment. Manufacturing of modern and innovative production scheduling methods is becoming mandatory in today's digital production[5, 6].

The traditional production planning and scheduling methods do not deploy robotic process automation to anticipates potential risks through the use of time and cost-oriented failure model (tcFMEA). The following section explains the most common scheduling methods available.

2.3. Production Scheduling Techniques

Research on scheduling techniques has been published for many years. The most commonly used techniques include: Kanban[13], Dispatching Rule[4], branch and bound method[17], MRP, Analytical Methods or Exact Method comprising (N Workers, One Machine, N Workers, Two Machines, N Jobs, Three Machines, Two Jobs, M Machines)[12, 3, 10], Mathematical Scheduling Optimization(Linear Programming Optimization) There is still a promising line of intensive research to come up with productivity planning and scheduling that will characterize fast delivery and optimized output costs[3, 10, 12].

2.4. Robotic Process Automation in Industry 4.0

Intelligent machines and raw materials are required to interact with each other in industry 4.0 and to drive production processes cooperatively. Output should be versatile and individualized, in particular in mass production. The cooperation

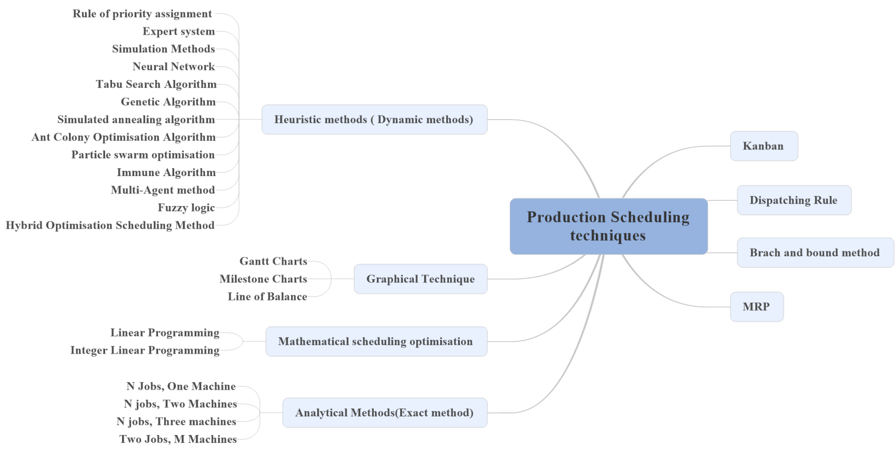

Figure 2: Production Scheduling techniques[Own Source]

of computers, parts and raw materials would be highly dependent on the cyber-physical network of all items in development. Around the same time, sensors and actuators will be part of the Internet of Things. The cyber-physical system (CPS) is a collective network of digital elements governing physical entities. CPS are physical and engineered systems whose operations are monitored, organized, managed and integrated by the computing and communication core[2] and defined by its three key characteristics; intelligence, connectivity and response to changes[11]. The real-time decision support system is a core component of Industry 4.0. In order to be successful, the decision support system also depends on the configuration of the robotic process automation (RPA).

Robotic Process Automation is a technology framework that allows computer software to partially or completely automate human processes that are manual, repetitive and rule-based. RPA allows a organization the opportunity to model a business process that is definable, repeatable and rules-based, and to appoint a "robot" program to handle the execution of that process. It is estimated that 22% of information technology works will be replaced by robotic process automation in the near future.[7]. **Robotic** is where machine mimics human actions, **process** is a sequence of steps to perform a task and **automation** is executing any meaningful task when done without any human interventions.

RPA does not involve any invention of software/technology for automating. The same RPA tool can be used to automate various projects involving different technologies and does not require any human intervention. In the market, there are more than 12 companies that are involved in RPA but the top three companies are Automate Anywhere Uipath and Blue Prism. Automate Anywhere is suggested to be good for Forward Office(FOR) and Back Ward Office Robotic (BOR), Uipath is doing well in FOR and Blue Prism is good at (BOR).

The main features of RPA are; **Microsoft automation.** Automating Microsoft Office applications may be the most used features of any RPA tool[1]. **GUI Automation.** This is the process of simulating mouse and keyboard actions on windows and controls Screen Scraping. This is the process of extracting text from websites and win32 apps. **Citrix Automation.** Surface/ Citrix Automation is used because you cannot access the elements that make up virtual machines.

2.5. Risk Analysis

Failure Mode and Effect Analysis (FMEA) is the most powerful and reliable method for analyzing risk analysis in general. However, time and cost-oriented failure model (tcFMEA) is used in section 3 because the application of FMEA is restricted and weak[14].

The accuracy of the risk analysis depends very strongly on the correct use of the probability distributions to accurately express the complexity, randomness and volatility of the problem. Program Evaluation and Review Technique (PERT), Four Parameters Beta (Beta4) distributions, Triangle, Beta are the most appropriate distributions that can represent the time and cost of production planning and scheduling in the manufacturing sector.

2.6. Prerequisites of Production Planning and Scheduling in industries 4.0

In order for the production planning and scheduling in real-time decision support system to work correctly, it highly depends on the two requirements which includes;

The criteria for models: Include, the start date and finish of the job, the workload time, the maximum completion time for each job, workload weight, the preparation time for the work to be started, the number of job steps to be completed, the start time of the job to the respective machine.

Prerequisites for the manufacturing environment: involve, Forecast market demand, real time technology (works, machines), commodity data, time-take of each unit, case records, Internet of things (connectivity), captors and actuators, Mono-free output, monitoring systems, real-time inventory levels and accessible ERP systems. The development cycle needs the manufacturing environment.

3. Conceptual Real-Time Decision Support System for Scheduling Optimization Process

Figure 3, shows the purely conceptual model of the Real-time decision support system, which starts by receiving a job from the database (cloud emails) and is documented in the ERP. The data to be entered during registration includes Job ID, customer names, due dates, processing steps, time taken, job values and other

relevant information. The next step is to check the availability of all resources (machinery, labour and logistics equipment) for jobs. In case of Machinery resources availability the flowing two factor are used;
Machine availability factor(MAF) for job i in machine j. MAF is a measure of how busy are the machines at respective time of scheduling. let S_{ij} = Setup time of job i in machine j,N= Number of set-ups ,like wise to Q_{ij} = Quantity of job i into machine j , CT_{ij}= Cycle time of job i in machine j. Where EMC = Effective

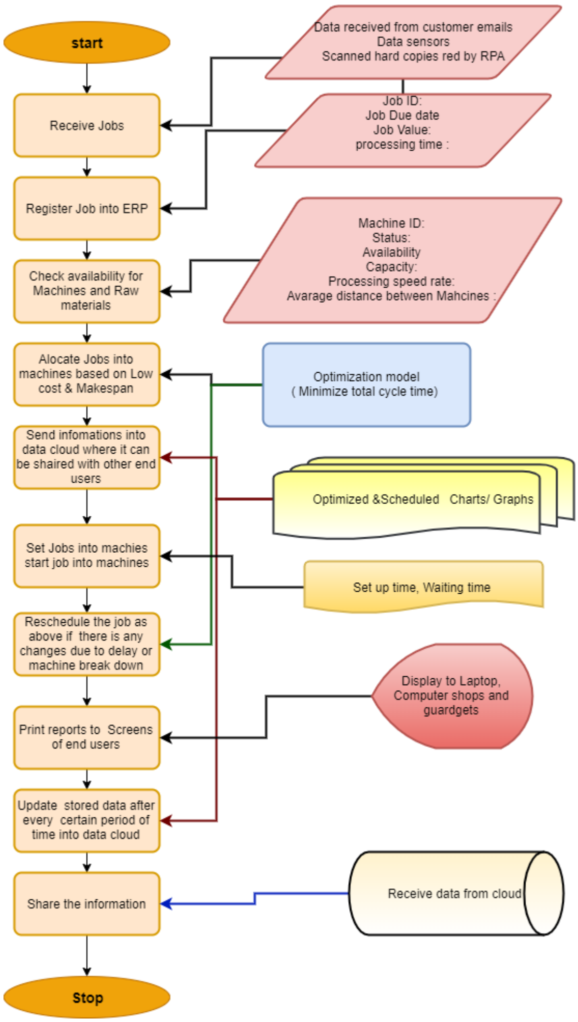

Figure 3: Conceptual Real time Decision Support System by RPA.[Own Source]

machine capacity and NM=Number of machines

$$(\text{MAF}) = \frac{\sum_{K=1}^{K} S_{ij} \times N_{ij} + Q_{ij} \times CT_{ij}}{EMC \times NM}$$

Job Operational cost factor(JOCF) for job i in machine j is a ratio which is obtained by summation of all costs in a respective machine divided by total cost. MC= Material movement cost,SC = Setup cost,RC= Run cost and TC= Total cost of job i and machine j

$$\text{OCF} = \frac{\sum_{n=1}^{n} MC_{ij} + SC_{ij} + RC_{ij}}{TC}$$

The most critical next step is the model itself, which must coordinate all the jobs associated with its operations in such a way as to reduce the total cycle time(span) of all the jobs that are the target of this project. After the arrangement and assignment of machine employees, risk factors shall be defined, classified, and their scenarios shall be calculated. The next step is to model the risk scheduling framework. If the scheduling tests are successful and correct, they will be processed; otherwise, the previous steps will have to be repeated. The RPA is also responsible for sharing information in real-time computers and handsets during the execution of operations. Job is registered and stored at any time in the cloud. Both feedback and future decisions can be taken based on real-time data obtained and shared by RPA.

4. Summaries

Through this paper, the study of current planning, scheduling, and risk analysis in manufacturing activities have been carried out in order to highlight the challenges and opportunities available to the public. The development of a strictly conceptual hybrid real-time decision support system model involving sophisticated and intelligent planning and scheduling techniques and applied robotic process automation (RPA) has been accomplished in order to address the challenges.RPA forecasts potential risks through the use of time and cost-oriented failure model (tcFMEA) and takes them into account during preparation.

The goal is to increase the total average production time by enhancing production planning and scheduling in the manufacturing sector.Qualitative data are obtained from literature reviews of different academic sources (newspapers, journal journals, lectures, books and other online platforms) along with intuitive thought. A list of twenty-six preparation approaches is read in the literature and, separately, more than seventeen manufacturing criteria are identified, and 11 criteria are subsequently identified. Then more than 17 model requirements are described and customized to only 17 and, finally, conceptual model steps are created.

A list of scheduling options has been compared. The design and production requirements relevant to the selection of the best scheduling program by the AHP analysis have been put in place. Furthermore, the computational model is developed, as shown in 3. To conduct the job accurately and on time in the company, it requires hard-working workers and the appropriate information in the right period at the right place.

5. Future research

The future study will involve an analytical, hierarchical process analysis of scheduling methods. The best selected method will be advanced into industrial practical case study.

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