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Determining Potential Options for Production Efficiency Maximization

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Abstract - Production planning can be described as creating a strategy for the design and manufacturing of a certain good or service. Manufacturing of a product involves many processes with each process having its own requirement of manpower and equipment. Each of these processes are bounded by time limitations in order to boost production capacity. And boosting of production capacity has to be done is such a way that it involves adequate management of costs in order to maximize profits. Also, boosting of production capacity is solely not dependent on time, it is also dependent upon other factors such as employee skill level, work to be done, material quality etc. So, building of a model on similar lines will allow for successful prediction of what process must be done and when it must be done and how it must be done, enabling us to successfully maximize profits along with increase in production capacity.

***Key Words*:** Production, Manufacturing, Profit, Scheduling, Conveyor Belt

1. INTRODUCTION

Production planning has been an essential part of the manufacturing industry since the early 19th century. Its main purpose is to create an efficient process for producing goods that meet both customer and organizational needs. This involves planning and managing the supply chain, raw materials, employees, and physical space required for the manufacturing process.

Production plans were simple earlier because factories were small and produced limited products in large batches. However, as production lines and manufacturing efforts became more complex, more involved production planning became necessary. By the beginning of the 20th century, production planning had evolved to focus on optimizing the production processes to ensure an even production flow at the minimum possible cost.

Today, production planning is more important than ever because it helps organizations make their production processes as efficient as possible to meet customer and organizational needs. With the evolution of technology and the availability of more information, production planning has become more precise, enabling better communication and monitoring of the production process. The products themselves and customer expectations have also changed, making it essential for organizations to weigh more information when creating their production plans. Overall, production planning remains a critical part of the manufacturing industry and helps organizations maximize efficiency and profitability.

2. LITERATURE REVIEW

Conducting a wide range of problem analysis on production line work in a short time and standardizing its operations has become a major difficulty for enterprises to improve work efficiency. Using the example of M Company's Rail car assembly workshop, an article published in PNTIM 2019 highlights the various problems encountered during the trial operation of a manufacturing line. Analysing and improving each process individually can be a huge workload and may not effectively identify common problem factors. To overcome this dilemma, machine learning K-Means algorithm was used to conduct clustering analysis on realistic production line data. The algorithm identifies common factors across various processes, enabling enterprises to conduct unified processing and save time and costs.[1]

Another research addresses the challenge of supply disruptions in inventory planning, which can lead to excess costs and difficulty in maintaining suitable stock levels. The authors argue for the use of reorder intervals rather than lot sizes to better reflect the frequency of production and simplify mathematical modelling. They also advocate for a more integrated approach to determining the economic lot size for raw materials and manufacturing batch size. The research formulates the problem in terms of production intervals and uses a genetic algorithm to optimize production cycles and minimize inventory costs. The production-inventory policy is modelled into four stages and assumes disruptions obey the Exponential Distribution. The genetic algorithm was used to solve a production-inventory problem with backlog, time-varied demand, and imperfect production due to defects. The algorithm optimized the number of production cycles and generated an aggregative production plan to minimize the total inventory cost. The result is an aggregative production plan that can help manufacturers better manage their inventory in the face of disruptions. The research was limited to equal duration cycle periods and linear demand patterns but can be extended to dynamic cycle periods and different demand models for real-time modification.[2]

3. PROBLEM STATEMENT

Assembly line scheduling is important for any production company for several reasons like maximizing the efficiency, cost reduction, meeting customer demand, quality control etc. Efficient assembly line scheduling can help companies reduce costs associated with production. By optimizing the production process, companies can minimize the amount of labour, materials, and equipment needed to produce their products, which can lead to significant cost savings. In our case we take into consideration a company manufacturing electronic products like torches, mosquito racquets and AC/DC Bulbs etc. having multiple production lines (conveyor belts). Within the factory each assembly line performs different process at a particular pace. Each product undergoes through different number of processes like soldering, joining of moulds, screwing, etc. throughout the production line. Individual processes have their own execution time adding up to a product's total execution time. Each assembly line needs to execute the steps for a particular product efficiently to maintain quality. Various important factors like the quantity of order, due date, raw materials, availability of labours needs to be taken care of. Hence, with our work, we attempt to provide a successful model which helps with the decision of order acceptance or rejection and displays which order to be run and when it should be run on which production line so that the customer demands are successfully met, and profits maximized for the company.

4. METHODOLOGY

With the goal of meeting deadlines and reducing downtime on the assembly lines, the algorithm in consideration divides a list of orders across two assembly lines. To efficiently assign each order to one of the assembly lines, the algorithm employs a number of strategies. To assign the orders in a sequence that satisfies each deadline, the algorithm first sorts the list of orders according to their due dates. This is an essential step since it enables ranking of orders according to their importance.

The algorithm then repeatedly goes through each order in the sorted list and decides where to put it on the assembly line such that there is as little downtime and workload as possible. This maintains the balance of the assembly lines, preventing one from becoming overloaded while the other is idle. The algorithm takes the order's due date and the current time on the assembly line into account while calculating the execution time for each order. It can decide when each order can be processed and finished by taking into consideration the assembly line's operational hours. The algorithm will not assign an order to an assembly line if it cannot be completed in the specified time.

The algorithm then publishes the start and end times for each order once it has been assigned to a particular assembly line. The user will be able to know when each order will be finished and whether it will be finished in the allocated. The algorithm responds with True if all orders can be executed by their due dates. Otherwise, it responds with False. The capacity of this approach to be used to calculate the potential minimum due date for a new order to be accepted by the algorithm is one of its advantages. The algorithm can determine when the new order can be finished and whether it can be done within the allocated time by examining the workload and downtime on the assembly lines.

In general, the algorithm devised is an effective tool for controlling how orders are distributed throughout assembly lines. The algorithm makes sure that all orders are finished on schedule and that idle time on the assembly lines is kept to a minimum by prioritising the orders and optimising the allocation process.

5. ALGORITHM

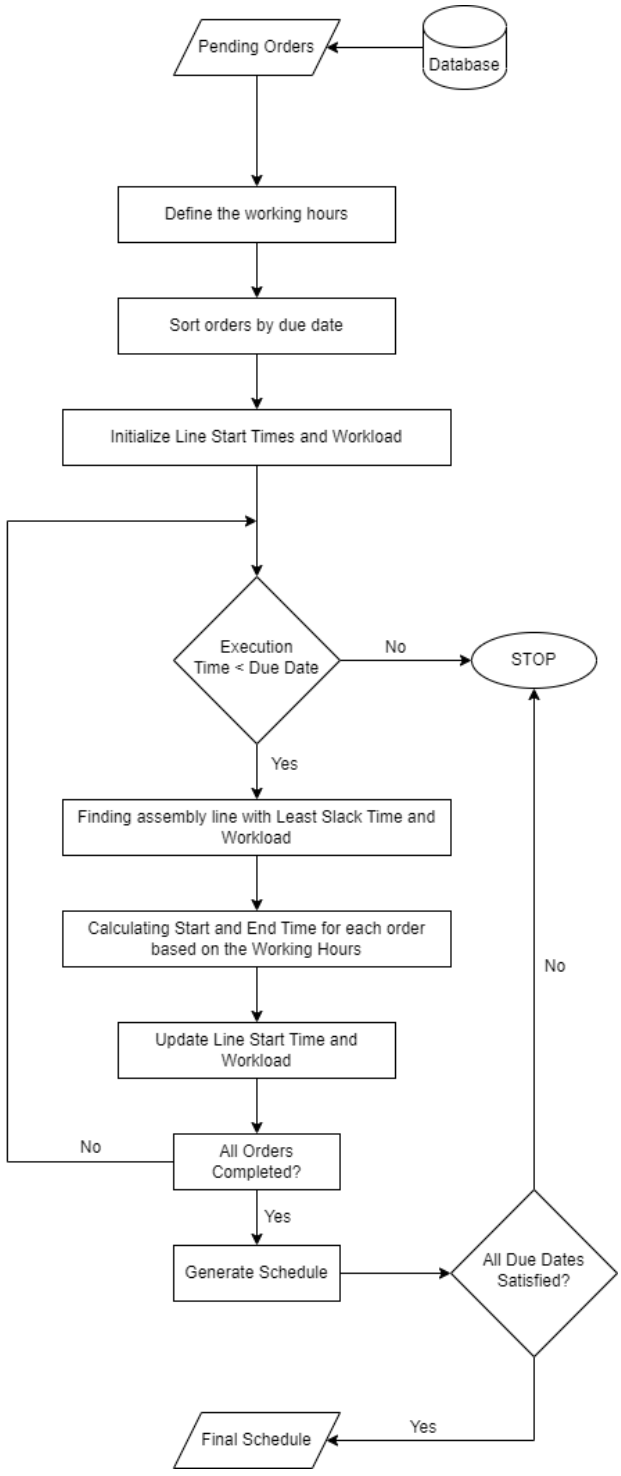

Fig -1: Algorithm for Scheduling Orders

The Algorithm can be described as follows:

1) The class OrderScheduler is initialized with two working time intervals for each assembly line.

2) The schedule_orders method takes a list of orders and sorts them based on their due dates.
3) The method then initializes the start time and workload for each assembly line to be 8:00 AM and zero, respectively.
4) For each order, the method calculates the execution time required and the total time available before the due date.
5) It finds the assembly line with the least slack time and workload for the current order based on the start time and the maximum workload of the other line.
6) If the due date cannot be satisfied for the current order, the method sets a flag to indicate that the scheduling is not feasible.
7) Otherwise, the method assigns the order to the selected assembly line and calculates the start and end times for each order based on the available working hours.
8) The method updates the start time and workload for the selected assembly line and adds the order's details to the schedule list.
9) If all orders can be scheduled, the method returns the schedule list; otherwise, it returns False.

Overall, the algorithm involves iteratively assigning orders to the assembly lines based on their due dates and available working time, and checking if the due dates can be satisfied for each order. It into account the remaining execution time for an order that spans multiple days and adjusts the start and end times accordingly.

5. RESULT

For a given set of input values to the algorithm, it appropriately schedules the orders to the production lines in the most optimized way. Let us consider the following set of inputs given to the algorithm.

Table -1: Input values to algorithm

Order ID	Product ID	Manufacturing Time Required for a Box (in Min)	Quantity (Boxes)	Due Date
1	AD-352	20	60	25/05/2023
2	AD-331	27	30	18/05/2023
3	AD-312	20	60	16/05/2023
4	AD-1011	15	20	19/04/2023
5	AD-5731	24	60	18/05/2023
6	AD-311	23	80	19/06/2023

The algorithm runs and takes into consideration the manufacturing time, due date, quantity to be produced etc. and then produces the following schedule for production.

Table -2: Algorithm Output as Schedule

Order ID	Assembly Line	Start Date	Start Time	End Date	End Time
4	1	16/04/2023	8:00 AM	16/04/2023	2:00 PM
3	2	16/04/2023	8:00 AM	18/04/2023	1:00 PM
2	1	16/04/2023	2:00 PM	18/04/2023	10:30 AM
5	1	18/04/2023	10:30 AM	21/04/2023	10:00 AM
1	2	18/04/2023	1:00 PM	20/04/2023	5:00 PM
6	2	21/04/2023	8:00 AM	24/04/2023	3:40 PM

Careful observation into this schedule makes it certain that this is one of the best ways to schedule the orders in order to meet customer demands at earliest and at the same time make it profitable for the company by optimizing it according to the company needs.

6. CONCLUSIONS

From proper analysis of positive points and constraints of the algorithm devised, we can conclude that the algorithm employs various strategies to assign the orders in a sequence that satisfies each deadline, displays which order to run, and when it should be run on which production line to meet the customer demands and company requirements. Effective production planning plays a critical role in maximizing efficiency and profitability in the manufacturing industry and is essential for organizations to remain competitive in today's rapidly evolving business environment.

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