Analysis of Production Scheduling and Line Balancing for Polycarbonate Lens Production

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Abstract

Production planning and scheduling are generally treated sequentially. Based on a critical review of the application of simulation techniques to Production Planning and Control (PPC) problems between 2002 and 2014, the literature was systematically narrowed from about 2,250 to 131. The five problems considered in PPC are facility resource planning, capacity planning, work planning , process planning and production scheduling. The development of expert systems in scheduling poses many problems and many different approaches have been tried in prototyping systems. One of the manufacturing companies that produce polycarbonate lenses applies a make to order system. Based on the production scheduling that has been applied, the order completion target has not been met for 30 days. Based on the problem in production scheduling, analyzing by production scheduling and line balancing for polycarbonate lens production. So it can meet the target completion of orders that have been set.

Keywords
Production Scheduling, Queue System, Line Balancing, Takt Time

1. Introduction

Production planning and scheduling are generally carried out sequentially. Production planning is the basis for manufacturing companies, to determine the type and quantity of products to be produced to meet demand (VenKateswaran 2004). Scheduling is an important application in expert systems, in development it still creates many problems and many different approaches (Maccarthy and Jou 1995). In manufacturing companies, the part that regulates production planning and scheduling is Production Planning Control (PPC). In February 2022, a polycarbonate lens manufacturing company received 32,308 customer orders with a variety of product types of 299 products in 39,10 days of the 30-day completion target. The part that regulates production scheduling in the company is the PPC section. Based on a critical review of the application of simulation techniques to PPC problems between 2002 and 2014, a systematically narrowed literature was filtered from about 2250 to 131. Five applications (Facility resource planning, capacity planning, job planning, process planning and production scheduling) were considered issues. production planning (Jeon and Kim 2016). Researchers take one problem from production planning, namely production scheduling to analyze production scheduling in fulfilling customer orders with a target of 30 days from the time the order is received.

2. Literature Review

Based on previous research on production scheduling problems, the background is delays in delivery (Nur Amalia and Sofyan 2022), products with faster processes are delayed due to First Come First Serve (FCFS) rules (Sulaksmi, Kesy Garside, and Hadziqah 2014), complicated product manufacturing processes (Sodikin and Mashuri 2012) and sufficient production capacity but cannot meet customer demands on time (Annisya and Saifudin 2020). From previous research references production scheduling is very influential on timeliness to meet customer demand. The researcher tries to identify the method used by previous researchers consisting of the Earliest Due Date (EDD), and First Come First Serve. However, the condition of the problem is that the manufacturing company where the researcher is based has data order criteria with the same due date and there is only 1 order from 1 customer, so the First Come First Serve and Earliest Due Date systems cannot apply. Data that can be processed from February 2022 orders is based on the fastest processing time and the longest processing time, so researchers will use another queuing system method that focuses on processing time by comparing the Short Processing Time and Long Processing Time from the

order completion time and the utilization value of the production schedule. Research that uses the Short Processing Time and Long Processing Time methods only uses existing resources and schedules them, so there is no calculation of the proper use of resources to work on orders received before scheduling them. This research is similar to that carried out by (Fadli and Sulistiyowati 2021) and (Safitri 2019) , so researchers are looking for additional reference methods for calculating resources used for production before scheduling production. Using the line balancing method, namely takt time (Wirawan 2018) to calculate the resources needed for production before using the SPT and LPT methods.

3. Methods

Based on the problem of the order completion time in February 2022, the researchers used the takt time method to determine the standard processing time based on the number of orders obtained with the time available. After the takt time is obtained, the researcher will determine whether the processing time in each production process is the same or below the takt time. Next, determine the resources used to fulfill the order completion time for 30 days based on the takt time. So that the order completion time has met the target. To determine the sequence of production scheduling after production resources have been determined, the researcher uses a queuing system analysis using Short Processing Time (SPT) and Long Processing Time (LPT) and looks at the utilization value and order completion time, to determine the best method for scheduling polycarbonate lens production on February 2022.

4. Data Collections

To meet the needs of data analysis, the researchers collected data related to takt time calculations and queuing system calculations. Data collected to process takt time data, including the number of orders, start of production and available production time. The data collection from order on February 2022 (Table 1, 2 and 3).

Table 1. Data For Calculation Available Time

Item	Time for 1 Day	Time for 30 Days
Working Time (3 Shift)	86,400	2,592,000
Break Time (1 Hour/Shift)	10,800	324,000

Table 2. Data Demand & Start Production

Item	Quantity (Pcs)
Demand	32,308
Start Production	56,680

Table 3. Resources Production and Cycle Time Process

Current State	Molding	First Degating	Coating	Oven	Tint Test	Second Degating	QC
Lot Size (Pcs)	4	4	40	40	40	40	40
Cycle Time/Lot Size (s/Pcs)	113,08	22,00	210,00	250,00	25,00	260,00	288,00
Machine (Pcs)	1		1	1		1	
Man (Person)		1			1		1
Total Resources	1	1	1	1	1	1	1

The data needed to use the SPT and LPT queuing system methods includes the number of products, the number of orders for each product, the cycle time of each production process and the total completion time for each product. There are 299 types of products, each of which has a different total completion time (Table 4).

Table 4. Order Type and Total Completion Time

No.	Product	Qty. Order	Start	Cycle Time (s)							Total Completion Time (s)	Total Completion Time (Days)
				Molding	First Degating	Coating	Oven	Tint Test	Second Degating	QC		
1	Lens Type A	347	680	100.00	22.00	210.00	250.00	25.00	260.00	288.00	30,912.84	0.36
2	Lens Type B	213	280	101.00	22.00	210.00	250.00	25.00	260.00	288.00	12,728.82	0.15
3	Lens Type C	217	400	101.00	22.00	210.00	250.00	25.00	260.00	288.00	18,184.02	0.21
297	Lens Type KK	7	120	145.00	22.00	210.00	250.00	25.00	260.00	288.00	5,455.21	0.06
298	Lens Type KL	3	40	145.00	22.00	210.00	250.00	25.00	260.00	288.00	1,818.40	0.02
299	Lens Type KM	3	40	165.00	22.00	210.00	250.00	25.00	260.00	288.00	1,818.40	0.02

5. Results and Discussion

5.1 Takt Time

Based on calculations using the takt time method, the time required for each production process is 40 s/pcs, when compared to the actual cycle time in each process, it meets the standard takt time to fulfill orders (Table 5; Figure 1 and 2).

Table 5. Current State

Current State	Molding	First Degating	Coating	Oven	Tint Test	Second Degating	QC	Makespan (Days)
Start (Pcs)	56,680	56,680	56,680	56,680	56,680	56,680	56,680	
Lot Size (Pcs)	4	4	40	40	40	40	40	
Cycle Time/Lot Size (s/Pcs)	113,08	22,00	210,00	250,00	25,00	260,00	288,00	
Cycle Time/Product (s/Pcs)	28.27	5.50	5.25	6.25	0.63	6.50	7.20	
Takt Time (s/Pcs)	40	40	40	40	40	40	40	
Total Workdays	18.55	3.61	3.44	4.10	0.41	4.26	4.72	**39.10**
Machine (Pcs)	1		1	1		1		
Man (Person)		1			1		1	
Total Resources	1	1	1	1	1	1	1	

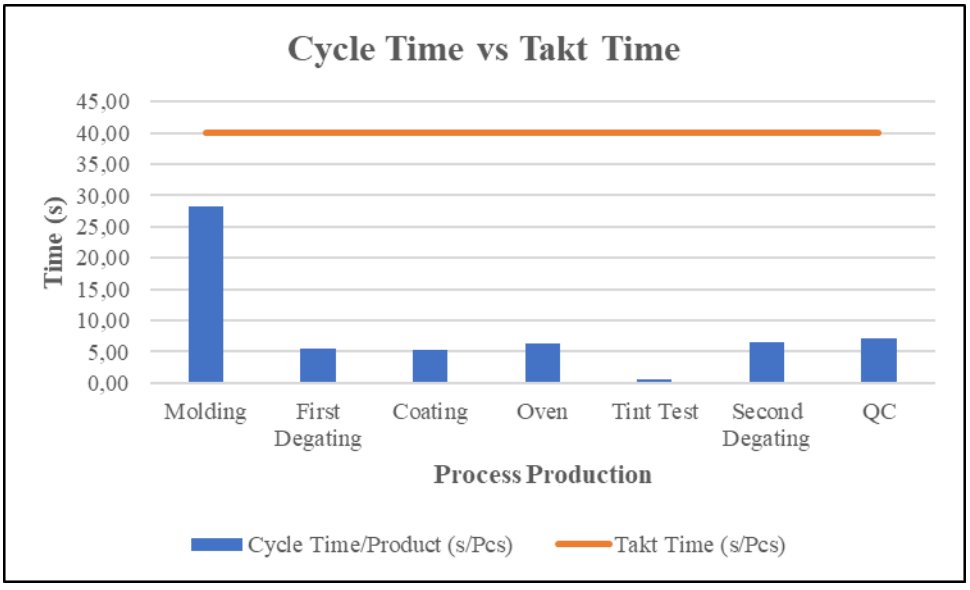

Figure 1. Cycle Time Vs Takt Time Chart

However, if you look at the total time needed to complete the order, it is not enough to meet the 30 day order fulfillment target, so it is necessary to add resources to the molding process into 2 machines. So the time needed to fulfill the order becomes 29.82 days (Table 6).

Table 6. Future State

Future State	Molding	First Degating	Coating	Oven	Tint Test	Second Degating	QC	Makespan (Days)
Start (Pcs)	56,680	56,680	56,680	56,680	56,680	56,680	56,680	
Lot Size (Pcs)	4	4	40	40	40	40	40	
Cycle Time/Lot Size (s/Pcs)	113.08	22.00	210.00	250.00	25.00	260.00	288.00	
Cycle Time/Product (s/Pcs)	14.14	5.50	5.25	6.25	0.63	6.50	7.20	
Takt Time (s/Pcs)	40	40	40	40	40	40	40	
Total Workdays	9.27	3.61	3.44	4.10	0.41	4.26	4.72	**29.82**
Machine (Pcs)	2		1	1		1		
Man (Person)		1			1		1	
Total Resources	2	1	1	1	1	1	1	

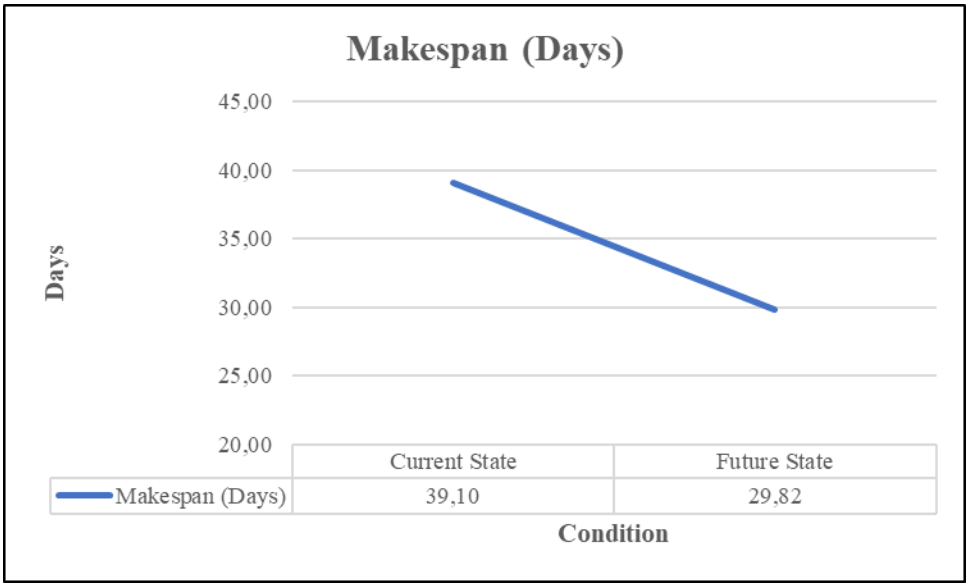

Figure 2. Makespan Chart

5.2 Queue System

From the calculation of the previous takt time, the order completion time has been obtained for 29.82 days. Furthermore, to make a production schedule after determining the resources used, a queuing system is used to see how much the average delay is in processing orders and the utilization value of the schedule. The calculation results show that the SPT method has a greater utilization value than the LPT method with a value of 1.27%. So that the SPT method will be chosen for production scheduling (Table 7).

Table 7. Queue System Calculation Results

Queue System	Average Completion Time (Days)	Utilization (%)	Average Number of Jobs in The System	Average Lateness (Days)	Makespan (Days)
Current State	20.72	0.63%	158.49	1.43	39.10
SPT	7.86	1.27%	78.83	0.00	29.82
LPT	22.06	0.45%	221.17	0.00	29.82

6. Conclusion

Based on research results in analyzing polycarbonate lens production scheduling using the line balancing method (takt time), to fulfill an order of 32,308 pcs with a start of production of 56,680 pcs requires the addition of molding machines to 2 machines. So that customer orders will be fulfilled for 29.82 days from the target of 30 days. By using the queuing system method, the short processing time method is more efficient to use in the scheduling, because it has

a utilization value of 1.27% compared to the Long Process Time method of 0.45%. However, this research only covers 1 type of order from 1 customer, only has 1 due date and has not included setup time as a calculation of the total production time.

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Biographies

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