Machine Learning Application in Manufacturing System

< Experimental result & analysis >

1. Report on the simulation results.

		Part Quality Percentage			
		65%	75%	85%	95%
Good	TH	62.5	109.7	176	248.3
Bad	Cell 1	66.2	55.3	35.8	14.7
	Cell 2	76.3	60.9	40.3	16.4
	Cell 3	66.4	53.2	40.8	13.8
	Cell 4	62	54.3	41	11.6

Part quality in manufacturing refers to the degree in which a manufactured part meets the specified standards and requirements for its intended use. High part quality implies that the parts produced are consistent, reliable, and defect-free, whereas low part quality indicates that parts may have detects or deviations that could affect its performance.

As the part quality percentage increases, so does the throughput of non-defective parts. This indicates that higher part quality has a significantly positive impact on the overall throughput of the manufacturing process. On the other hand, as part quality increases, the number of defects produced by each cell decreases which indicates enhanced manufacturing efficiency and higher quality control. All cells show a similar tendency for the number of defects to decrease as part quality improves. This consistency across cells shows the importance of part quality in achieving high manufacturing standards.

< Discussion & conclusion >

(1) Discuss ways to improve the OEE in perspective of availability and performance and show the simulation results with improvement.

Overall Equipment Effectiveness (OEE) is the standard measurement of manufacturing productivity, and is calculated by multiplying availability, performance, and quality. Thus, improving any of the three factors can directly lead to increasing throughput.

Specifically, in the perspective of availability, availability takes into account of all events that causes stop, such as unplanned and planned stops. So, reducing downtime can be a way to improve availability, as it minimizes disruption to production.

To verify that reducing downtime increases throughput, the table below shows the result of series of simulations, having differences is downtime.

Uptime = 100 min Quality 95%		Downtime			
		30 minutes	20 minutes	10 minutes	0 minutes
Good	TH	173.7	195.3	221.4	248.3
Bad	Cell 1	12.8	11.5	13	14.7
	Cell 2	10.6	12.2	12.6	16.4
	Cell 3	10.9	11.4	13.7	13.8
	Cell 4	10.8	10.8	11.5	11.6

It is observable that the decrease in downtime leads to the increase in defect-free throughput.

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(2) Suggest other data that can be collected in the manufacturing system to improve the OEE.

1. Production process data: This includes cycle time measurements, which are the time it takes to complete a single production cycle, tracking lead time from the start of production to the delivery of finished products, and recording setup time for machine settings. Collecting this data allows manufacturers to optimize the production workflow, which reduce delays and improving overall process efficiency.

2. Machine Utilization Data: This includes tracking of idle time to monitor periods during which machines are not in use, measuring the actual uptime of each machine, and recording the causes of both downtimes. This data helps to understand machine's operational efficiency and identifying areas for improvement.

3. Quality data: This involves monitoring the number of defective parts by tracking the defective rates, measuring rework time to determine the effort required to rework defective parts, and recording scrap rates to quantify the amount of scrap generated during manufacturing. Manufacturers can analyze quality data to resolve quality issues, reducing waste and improving product quality.

4. Performance data: This includes measuring the throughput rate to determine the rate at which a product is produced, tracking instances of speed loss at which machines operate at speeds below the maximum speed, and recording the frequency and duration of minor stops. Collecting and analyzing

performance data can help in identifying bottlenecks, which can speed production and better utilize manufacturing resources.

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(3) Discuss about the advantages of using machine learning algorithm and data analytic in the manufacturing system (Referring back to Lab #1's discussion question about the EOQ and (Q, r) model's limitations).

Models, such as EOQ and (Q, r), have several limitations that decreases their effectiveness in reality manufacturing environments. These models often rely on simplifying assumptions, such as constant demand and lead times, which fail to capture the complexities and variabilities inevitable in real-world operations. Also, their static nature leads to poor adaptations to fluctuations in various situations. Furthermore, traditional models typically lack synchronization with real-time data, resulting in inefficiencies, such as delays, in responding to changes in the manufacturing process.

Advantages of Machine Learning and Data Analytics

1. Demand Forecasting: Machine learning models can easily analyze large datasets to detect patterns and trends, enabling more accurate demand forecasts. These models can also adapt to changes in demand patterns, seasonality, and trends. Improved accuracy and adaptability reduce inventory exhaustion and inventory oversupply, thereby enhancing the balance between supply and demand.

2. Predictive Maintenance: Machine learning algorithms can predict equipment failures in advance, detect them early, and reduce unplanned downtime. Data analytics can also determine optimal maintenance schedules based on past data and real-time monitoring. This leads to increased equipment availability, ultimately leading to higher OEE.

3. Process Optimization: Machine learning can optimize diverse manufacturing parameters such as resource allocation, production schedules, and process flows. Data analytics can also simulate different scenarios to assess the impact of changes and optimize decision-making. These capabilities minimize waste, reduce cycle time, and improve resource utilization and productivity.

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