MODAPTO [101091996]: Modular Manufacturing and Distributed Control via Interoperable Digital Twins

5.1.3 KPIs of Scheduling Optimization

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Key Performance Indicators (KPIs) provide quantitative measures to evaluate the effectiveness of production scheduling and guide optimization efforts. Well-designed KPIs not only assess current performance but also highlight improvement opportunities and help track progress over time. In modular manufacturing environments, KPIs must address both traditional scheduling concerns and the unique challenges of flexible, reconfigurable production systems.

The most relevant KPIs for production scheduling can be categorized into several groups:

Time-Based KPIs:

- **Makespan**: Total time from the start of the first job to the completion of the last job
- **Lead Time**: Time from order placement to delivery
- **Setup Time**: Total or average time spent changing over between different products
- **Idle Time**: Time when resources are available but not productive
- **Processing Time Efficiency**: Ratio of value-adding processing time to total time

Due Date Performance KPIs:

- **On-Time Delivery Rate**: Percentage of orders delivered by their promised due dates
- **Mean Tardiness**: Average delay across all late jobs
- **Maximum Tardiness**: Delay of the most late job
- **Tardiness Distribution**: Variance or standard deviation of tardiness across jobs
- **Resource Utilization KPIs:**
- **Machine Utilization**: Percentage of available time that machines are productive
- **Worker Utilization**: Efficiency of workforce deployment

- **Resource Balancing**: Variance in utilization rates across different resources
- **Inventory and Flow KPIs:**
- **Work-in-Process (WIP) Levels**: Quantity of inventory in the production system
- **Throughput Rate**: Units produced per time period
- **Inventory Turns**: Frequency of complete inventory replacement
- **Queue Lengths**: Average number of jobs waiting for processing at workstations

Economic KPIs:

- **Production Cost per Unit**: Total cost divided by production volume
- **Setup Cost**: Expenses associated with changeovers and setups
- **Tardiness Cost**: Penalties or opportunity costs from late deliveries
- **Utilization Cost**: Expenses related to under or over-utilization of resources
- **Total Schedule Cost**: Comprehensive measure combining various cost factors

By systematically tracking these KPIs, organizations can evaluate the effectiveness of their scheduling approaches, identify improvement opportunities, and make data-driven decisions about schedule optimization strategies. In modular manufacturing environments specifically, these metrics help balance the complex trade-offs between flexibility, efficiency, and responsiveness that define advanced production systems.