Garment Production Management

Week 13

Scheduling and sequencing

Lecturer: ***Dr. Shalemu Sharew (Associate Prof.)***

Bahir Dar University
Bahir Dar, Ethiopia

Recap-previous week

- Inventory management concepts
- Types of inventory
- Benefits of inventory management
- Inventory costs
- Inventory planning and control models

Lecture Learning Outcomes

1. Understand scheduling and sequencing concepts
2. Analyze scheduling strategies
3. Understand scheduling techniques and methods
4. Evaluate effective production schedules

Session outline

- Scheduling and sequencing concepts
- Scheduling strategies
- Scheduling techniques and methods
- Monitoring and control of production schedules
- Scheduling in garment industry

Sequencing and scheduling

What is Production Scheduling?

- Short-term, detailed plan for *what*, *where*, and *when* to produce
- Translates master production schedule into actionable tasks
- Assigns resources (machines, labor, materials) to specific orders
- Helps to optimize delivery, efficiency, and cost

Sequencing and scheduling

What is Sequencing?

- Determines the priority order of jobs at a single work center
- A critical sub-component of scheduling
- Example: If 5 orders arrive at a sewing machine, which one goes first?
- Poor sequencing creates bottlenecks and idle time

Sequencing and scheduling

Key Performance Indicators (KPIs) for Scheduling

- Make span: Total time to complete a set of jobs
- Flow time: Total time a job spends in the system
- Tardiness: How late a job is relative to its due date
- WIP (Work-in-Process): Number of partially completed units
- Utilization: % of time machines/workers are busy

Sequencing and scheduling

Trade-offs in scheduling

Efficiency vs. Fairness:

- Shortest Processing Time (SPT) is efficient but can starve large jobs
- Longest processing time (LPT) is fairer but slower

Speed vs. Cost:

- Overtime speeds up but increases expense

Utilization vs. Flexibility:

- High utilization doesn’t have flexibility for emergencies

Sequencing and scheduling

Overview of sequencing rules

- First Come, First Served(FCFS)
- Shortest Processing Time (SPT)
- Earliest Due Date (EDD)
- Critical Ratio (CR)
- Longest Processing Time(LPT)

Sequencing and scheduling

FCFS – First Come, First Served

- Process jobs in exact arrival order
- Advantages: Simple, perceived as fair by customers
- Disadvantages: Ignores due dates and processing time; can cause long delays for short jobs
- Used for service desks, fast food, administrative workflows

Sequencing rules

Shortest processing time (SPT)

- Prioritize the job with the smallest processing time first
- Minimizes average flow time, reduces WIP
- Long jobs may get delayed indefinitely (starvation)
- Suitable to reducing average lateness when due dates are similar

Sequencing rules

Earliest due date (EDD)

- Prioritize the job with the closest delivery deadline.
- Maximizes on-time delivery percentage.
- Ignores processing time; a long job might make many others late.
- Useful when due dates vary widely but processing times are similar.

Sequencing rules

CR – Critical Ratio

- Formula: $\boldsymbol{CR} = \frac{\textit{Time Remaining Until Due}}{\textit{Remaining Processing Time}}$
- CR < 1: Job is already behind schedule
- CR = 1: Job is exactly on schedule
- CR > 1: Job is ahead of schedule
- Self-correcting; balances urgency and workload

Sequencing rules

Longest processing time (LPT)

- Prioritize the largest job first.
- Keeps bottleneck machines busy; prevents large jobs from being left behind.
- Increases average flow time for small jobs.
- Suitable for batch processes or when large orders have contractual penalties.

Comparison of sequencing rules

- *Example:* Four jobs with varying processing times and due dates
  - FCFS: Simple but often poor lateness or tardiness
  - SPT: Best average flow time
  - EDD: Best on-time performance
  - LPT: Worst average flow time but protects large jobs

Scheduling strategies

Finite vs. Infinite Scheduling

- **Infinite:**
  - Assumes unlimited resources
  - Easy to calculate but unrealistic
  - Creates overloads
- **Finite:**
  - Respects machine, labor, and tool capacity
  - More realistic
  - Essential for high-mix/low-volume production
  - Finite scheduling prevents scheduling chaos

Scheduling strategies

Forward vs. Backward Scheduling

- **Forward Scheduling:** Start now → push forward to find completion date
  - Use when start date is fixed
  - Timeline from today → completion
  - Material available → Setup → Run → Move → Completion.
  - If completion is after due date → need more resources or overtime.

- **Backward Scheduling:** Start from due date → work backward to find start time
  - Use when delivery date is non-negotiable

Example: Wedding dress (fixed event date) uses backward scheduling

Scheduling strategies

- **Backward Scheduling:** Start from due date → work backward to find start time
  - Use when delivery date is non-negotiable
  - Example: Wedding dress (fixed event date) uses backward scheduling
  - Timeline from due date ← today
  - Due date ← Final assembly ← Sub-assembly ← Material order
  - Reveals the latest possible start time
  - If today is later than that → job is already late

Scheduling methods

Lot splitting (Operation splitting)

- Break a batch into smaller sub-batches.
- Run sub-batches on **multiple machines simultaneously**.
- Reduces run time (makespan) but **increases** setup time.
- Example: Cut 100 shirts into 4 groups of 25 → sew on 4 parallel machines.

Operation overlapping

- Move a sub-batch to the next operation before the entire batch is finished
- Reduces idle time at downstream machines
- Requires careful coordination
- Example: After sewing 10 of 100 shirts, send those 10 immediately to buttoning

Scheduling methods

Lot Splitting + Overlapping Combined

- Powerful combination for reducing total lead time.
- Total time ≈ (Setup + run of first sub-batch) + (run of remaining sub-batches) - overlap
- Can cut lead time by 30–50% in repetitive manufacturing

Application of scheduling methods

- During high setup time and single bottleneck, avoid splitting; run as one lot
- When using multiple identical machines, lot splitting is appropriate
- If sequential operations, long run times, use operation overlapping
- If both conditions met, combine both

Monitoring and control in scheduling

Why monitor production schedules?

- Reality never matches the plan exactly (machine breakdowns, absenteeism, quality issues)
- Without monitoring: small deviations accumulate → missed due dates
- Closed-loop control: Plan → Execute → Measure → Correct → Re-plan

Monitoring and control in scheduling

Input/output (I/O) control

- Input: Work released to a work center per time period
- Output: Work completed by that work center per time period
- Balance rule: Output should equal planned input
- If Input > Output → WIP increases, queues grow, lead times stretch
- If Output < Planned → Bottleneck, need to reduce input or increase capacity

Monitoring and control in scheduling

Plan vs. Actual tracking

- Compare scheduled start/completion times to actual events
- Schedule adherence = % of operations finished within planned time window
- Real-time data sources: Machine sensors, barcode scans, operator mobile devices
- If adherence drops below 85%, trigger root cause analysis

Corrective actions for out of control schedules

Machine breakdown: Move job to alternative machine; conduct overtime on next shift

Quality rework: Insert rework into schedule as a new job

Absenteeism: Reassign tasks to available operators

Material delay: Re-sequence jobs that can run without the missing material

Application in garment industry

Unique Challenges in Garment Manufacturing

- Short product life cycles (fast fashion).
- High product mix with small batch sizes.
- Labor-intensive sewing operations (human variability).
- Frequent style changeovers (different threads, attachments, settings).
- Seasonality and demand volatility.

Industry 4.0 and 5.0 in scheduling

- Optimize machine utilization, minimize human intervention
- Balance machine efficiency with worker skills, fatigue, and ergonomics

Scheduling difficulty

Scheduling can be difficult due to:

- Variability in setup times, processing times, interruptions, and changes in the set of jobs
- No method to identify the optimal schedule
- Virtually impossible to sort through the vast number of possible alternatives to obtain the best schedule (except for small job sets)
- Scheduling is far from an exact science and is an on going task for a manager
- Computer technology reduces the challenge and makes real-time scheduling possible

Sequencing jobs in two work centers

Johnson's rule

- Minimize makespan for group of jobs processed on two machines (a two-machine flow shop)
- It also minimizes the total idle time at the work centers
- Several conditions should be satisfied for this rule:
    - Job time must be known and constant for each job at each work center
    - Job times must be independent of the job sequence
    - All jobs must follow the same two-step work sequence
    - A job must be completed at the first machine before moving to second machine

Sequencing jobs in two work centers

Application of Johnson's rule begins with:

- listing all jobs to be scheduled
- Identifying the job time at each workstation

The sequence is determined by the following steps:

- Step 1: Select the job with the shortest time

  If the shortest time is at the first work center, schedule that job first; if the time is at the second work center, schedule the job last. Break ties arbitrarily
- Step 2: Eliminate the job and its time from further consideration
- Step 3: Repeat steps 1 and 2, working toward the center of the sequence, until all jobs have been scheduled

Scheduling is high volume systems

- To achieve trade-offs among conflicting goals:
  - Efficient utilization of staff, equipment, and facilities
  - Minimization of customer waiting time, inventories, and process times
- Scheduling tasks is largely a function of the volume of system output
- High-volume systems require approaches substantially different from job shops
- Project scheduling requires different approaches
- Flow systems are high-volume systems where jobs follow the same sequence
- Flow shop scheduling (FSS) is scheduling for flow systems

Scheduling is high volume systems

- Flow shop scheduling is used when a set of jobs must pass through a series of machines or workstations in the same order
- Common in industries like apparel, textiles, automotive, electronics, and food processing, where the production process is highly standardized

  E.g, High-volume systems require FSS
- Due to the highly repetitive nature of these systems, many of the loading and sequence decisions are determined during the design of the system
- All items in high-volume systems follow virtually the same sequence of operations

Scheduling is high volume systems

The flow of work through the system is enhanced using:

- Highly specialized tools and equipment
- Arrangement of equipment
- Specialized material-handling equipment
- Division of labour

Scheduling is intermediate-volume systems

- Intermediate-volume system outputs fall between:
  - Standardized type of output of the high-volume systems
  - Made-to-order output of job shops
- Typically produce standard outputs
- If manufacturing is involved, the products may be for stock rather than for special order
- Since the volume of output is not large enough to justify continuous production, it is more economical to process items intermittently

Scheduling is intermediate-volume systems

- Setup costs may depend on the order in which jobs are processed
- Similar jobs may require less setup change between them
- E.g. jobs in a print shop may be sequenced by ink color to reduce the number of setups needed
- Other approaches to reduce setup costs are:
  - offline setups
  - snap-on parts
  - modular setups
  - flexible equipment designed to handle a variety of processing requirements

Scheduling is low-volume systems

- Low-volume systems (job shops) differ from high and intermediate-volume systems
- Products are made to order, and orders usually differ in terms of:
  - processing requirements; materials needed; processing time; processing sequence and setups
- Job-shop scheduling is usually complex
  - impossible to establish firm schedules before receiving the actual job orders
- Two basic issues for scheduling Job-shop processing: are:
  - How to distribute the workload among work centers
  - What job processing sequence to use

Scheduling & sequencing benefits in garment industry

Improve On-Time Delivery & Reduce expensive late shipment Costs

- Sequencing applies Earliest Due Date (EDD) rule to prioritize urgent buyer orders
- Scheduling allocates realistic start/end times considering
    - *Machine capacity*
    - *Operator availability*
    - *Buffer for unexpected delays (e.g., fabric inspection)*
- On-Time Delivery Performance (OTDP) improves
- Late penalties reduced
- Air freight costs avoided
- Higher buyer scorecards → more repeat orders

Scheduling & sequencing benefits in garment industry

Reduce Changeover Time & Increase Line Efficiency

- Sequencing groups purchase orders by:
  - Color family (light → dark)
  - Style type
  - Size run to minimize thread, folder, and needle changes
- Scheduling assigns start times and operator shifts to conduct changeovers during breaks not during peak production hours
- Changeover time can be reduced per style change
- Sewing line utilization increases
- More output without hiring additional operators

Scheduling & sequencing benefits in garment industry

Synchronize Cut–Sew–Finish Flow & Reduce WIP

- Sequencing orders cutting lots in a sequence that matches sewing line consumption – not faster, not slower
- Scheduling aligns start times of cutting, sewing, and finishing
  - Each operation begins exactly when the previous one has enough WIP
- Work-in-Progress (WIP) reduced
- Manufacturing lead time reduced
- Less risk of shade variation claims, color mixing, and lost pieces from excessive piles
- Enables smaller, more frequent orders (quick response to buyer)

Performance measures in Garment Scheduling

Measure	Benefit for the Garment Industry
Minimize makespan	Free up sewing lines for next season’s collection
Minimize mean flow time	Reduce WIP between cutting and finishing (prevents color mixing, shrinkage, or damage)
Minimize maximum tardiness	Avoid air freight costs (huge penalty – up to 30% of order value)
Minimize number of tardy jobs	Maintain buyer deadlines
Minimize total setup (changeover) time	Between style/color changes – lost production hours

Table 1: Scheduling performance measures in garment industry

Source: Author’s creation

Challenges in garment Scheduling

Department	Shop type	Scheduling challenge
Cutting	Batch (flow)	Sequence POs by fabric type + due date
Sewing	Flow line (or modular)	Line balancing; changeover between styles
Embroidery/Printing	Job shop (parallel machines)	Sequence by setup (color change, screen change)
Washing (denim)	Batch (parallel machines)	Machine availability; stone/chemical setup
Finishing (iron, QC, pack)	Flow line	Must match sewing line output; avoid pile-up

Table 2: Scheduling challenges in garment industry

Source: Author’s creation

Practical scheduling methods in garment industry

- Skill-based matching: Assign sewing tasks based on operator proficiency (not just machine availability)
- Style grouping: Use intelligent algorithms to group similar styles → reduce changeover time
- Bottleneck focus: The sewing machine line is the primary constraint; cut and finish around it.
- Real-time adaptation: When a skilled operator is absent, re-sequence tasks immediately

Summary

- Sequencing rules (FCFS, SPT, EDD, CR, LPT) solve local priority decisions
- Scheduling strategies (finite/infinite, forward/backward) set the overall approach
- Lot splitting and lot overlapping are scheduling methods that reduce lead time but add complexity
- Monitoring using input/output control and plan vs. actual tracking closes the loop
- Garment industry requires human-centric, skill-based, real-time scheduling
- The best schedule is one that is actually followed and adapted – not just calculated

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Thank You !

Contact email: shalemu14@gmail.com