Ch 16  Automated Production Lines

Sections:
1. Fundamentals of Automated Production Lines
2. Applications of Automated Production Lines
3. Analysis of Transfer Lines
Automated Production Lines

- High production of parts requiring multiple processing operations
- Fixed automation
- Applications:
  - Transfer lines used for machining
  - Robotic spot welding lines in automotive final assembly
  - Sheet metal stamping
  - Electroplating of metals
Where to Use Automated Production Lines

- **High product demand**
  - Requires large production quantities
- **Stable product design**
  - Difficult to change the sequence and content of processing operations once the line is built
- **Long product life**
  - At least several years
- **Multiple operations required on product**
  - The different operations are assigned to different workstations in the line
Benefits of Automated Production Lines

- Low direct labor content
- Low product cost
- High production rates
- Production lead time and work-in-process are minimized
- Factory floor space is minimized
Automated Production Line - Defined

“Fixed-routing manufacturing system that consists of multiple workstations linked together by a material handling system to transfer parts from one station to the next”

- Slowest workstation sets the pace of the line (bottleneck)
- Workpart transfer:
  - Palletized transfer line
    - Uses pallet fixtures to hold and move workparts between stations
  - Free transfer line
    - Part geometry allows transfer without pallet fixtures
Automated Production Line

General configuration of an automated production line consisting of $n$ automated workstations that perform processing operations.
System Configurations

- **In-line** - straight line arrangement of workstations
- **Segmented in-line** – two or more straight line segments, usually perpendicular to each other
- **Rotary indexing machine** (e.g., dial indexing machine)
Segmented In-Line Configurations

L-shaped layout

U-shaped layout

Rectangular configuration
Two Machining Transfer Lines
Rotary Indexing Machine

- Fixtures to locate parts
- Starting parts in
- Completed parts out
- Dial indexing table
Workpart Transfer Mechanisms

- Linear transfer systems:
  - Continuous motion – not common for automated systems
  - Synchronous motion – intermittent motion, all parts move simultaneously
  - Asynchronous motion – intermittent motion, parts move independently

- Rotary indexing mechanisms:
  - Geneva mechanism
  - Others
Belt-Driven Linear Transfer System

Side view of chain or steel belt-driven conveyor (over and under type) for linear transfer using work carriers
Walking Beam Transfer System

(1) Workparts
Next to locate workparts in stations
Fixed station beam
Transfer beam

(2) Motion of transfer beam
Transfer beam
Fixed station beam

(3) Motion of transfer beam
Transfer beam
Fixed station beam

(4) Motion of transfer beam
Fixed station beam
Transfer beam
Geneva Mechanism with Six Slots
Cam Mechanism to Drive Dial Indexing Table
Storage Buffers in Production Lines

“A location in the sequence of workstations where parts can be collected and temporarily stored before proceeding to subsequent downstream stations”

- Reasons for using storage buffers:
  - To reduce effect of station breakdowns
  - To provide a bank of parts to supply the line
  - To provide a place to put the output of the line
  - To allow curing time or other required delay
  - To smooth cycle time variations
  - To store parts between stages with different production rates
Storage Buffer

Storage buffer between two stages of a production line
Control Functions in an Automated Production Line

- **Sequence control**
  - To coordinate the sequence of actions of the transfer system and workstations

- **Safety monitoring**
  - To avoid hazardous operation for workers and equipment

- **Quality control**
  - To detect and possibly reject defective work units produced on the line
Applications of Automated Production Lines

- Transfer lines for machining
  - Synchronous or asynchronous workpart transport
  - Transport with or without pallet fixtures, depending on part geometry
  - Various monitoring and control features available
- Rotary transfer machines for machining
  - Variations include center column machine and trunnion machine
System Design Considerations

- **Building block approach:** machine tool companies specialize in transfer lines and indexing machines
  - User contracts for custom-engineered line
  - Standard modules such as workheads, feed units, transfer mechanisms, and bases
  - Called a unitized production line
- **Link line:** uses standard machine tools connected by specialized handling system
- Specialized processes often engineered by the user company
Standard Feed Units used with In-Line or Rotary Transfer Machines

(a) Horizontal feed drive unit, (b) angular feed drive unit, and (c) vertical column feed drive unit
Standard Milling Head

Milling head unit that attaches to one of the feed drive units in the previous slide
Rotary Transfer Machine (Plan View)

- Rotary transfer table
- Starting parts in
- Fixture to locate parts
- Completed parts out
- Horizontal spindle units (4)
Center Column Machine (Plan View)
Analysis of Transfer Lines

Three problem areas must be considered:

1. Line balancing
   - To divide the total work load among workstations as evenly as possible

2. Processing technology
   - Theory and principles about the manufacturing or assembly processes used on the line

3. System reliability - two cases:
   - Transfer lines with no internal parts storage
   - Transfer lines with internal storage buffers
What the Equations Tell Us –
Lines with No Storage Buffers

- As the number of workstations increases
  - Line efficiency and production rate are adversely affected
- As reliability of individual workstations decreases
  - Line efficiency and production rate are adversely affected
What the Equations Tell Us – Lines with Storage Buffers

- If $E_0$ and $E_\infty$ are nearly equal
  - Then little advantage is gained by adding a storage buffer
- If $E_\infty$ is much greater than $E_0$
  - Then adding a storage buffer may improve line performance significantly
- Storage buffers should be located so that production rates of the stages are about equal
- During operation, if any buffers are always empty or always full, then the buffer is serving little purpose
What the Equations Tell Us -
Lines with Storage Buffers

- The maximum possible efficiency is achieved by:
  - Setting the number of stages = number of stations
  - Using large buffer capacities
- The “law of diminishing returns” operates in multi-stage automated lines:
  - As the number of storage buffers is increased, line efficiency improves at an ever-decreasing rate
  - As storage buffer capacity is increased, line efficiency improves at an ever-decreasing rate