Assembly Workstation Design Issues

- Goals of this class
  - understand workstation elements
  - look at part feeding and presentation alternatives
  - design a process and a single station system for it
Assembly = Reduction in DoF Uncertainty

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Source:
What Happens in a Workstation

• An incomplete assembly arrives (or several at once)
• Parts to be assembled arrive
  – as single parts
  – as a subassembly
• Parts may have to be separated, oriented, given a final check
• Parts are joined to the assembly
• Assembly correctness is checked
• Documentation may have to be filled out
• The assembly is passed on to the next station
Major Issues

• Get done within the allowed cycle, which is usually short

• Avoid the three common errors
  – wrong part
  – correct part installed wrong, damaged, or causing damage to the rest of the assembly
  – bad part used anyway

• Error-proofing or poka-yoke

• Handle a lot of distractions
Cycle Time

• Varies from milliseconds for cigarettes to days for aircraft
• Components
  – work in/out
  – move to get tool
  – move to get part
  – move to insertion point
  – insert
  – move to get new tool
• Each move includes accel-steady speed-decel-creep
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Source:
Coordinate Transfer and Part Control

• Machine assembly requires transfer of coordinates
  – from where part is palletized to where it is gripped
  – from where it is gripped to where it mates
  – grip points may or may not be functional features
• These coordinates are usually on different locations on a part
• From each of these coordinates runs a chain of coordinate frames back around until they meet at the point of assembly
SOME OF THE MANY SOURCES OF ERROR THAT MUST BE CONTROLLED IN ORDER TO ACHIEVE SUCCESSFUL ASSEMBLY

A. PART CONSTRUCTION
B. PART JIGGING
C. JIG LOCATION
D. ROBOT ACCURACY AND CALIBRATION
E. TOOL SOCKET
F. PART GRIP
G. OFFLINE MODEL

\[ \Sigma = A + B + C + D + E + F + G \]
Some Important Decisions

• Choice of assembly “resource”
  – cost, reach, speed, multi-task capability, load cap, dexterity, etc: people, robots, dedicated/fixed

• Part presentation at the station or elsewhere
  – accuracy of palletizing or carrier strips almost the same as that of assembly
  – economics of palletizing: how/who; pipeline of WIP

• Serial vs parallel parts presentation
  – vibratory bowl or parts strip vs pallet

• Tool change vs multi-purpose tools
  – similar issues apply to manual and robotic
Small Parts Feeder

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Source:
Other Important Decisions

• Allocation of degrees of freedom
  – all in one place
  – shared between two, as in 4 DOF robot and 2 DOF workholder

• Combinations of fab and part arrangement with assembly
  – creates parts or subassemblies on the spot
  – examples: pre-assembly of valve keepers, spring winding, lubrication, sorting
Valve Keepers

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Source:
Workstation Layout

• Part presentation
  – Automatic feeders
  – Chutes loaded from opposite side
  – Bulk parts vs kits

• Station layout to provide
  – Parts and tools within easy reach
  – Things laid out in process sequence
  – Instructions - paper, video for each version
  – Instructions - what version is this
  – Documentation - tests performed, parts installed

• Line layout to provide
  – Space for materials at lineside
  – Space for transporters
Sony APOS

- Offline shakers fill pallets (~ 10” x 12”)
- Part jams, if any, occur off line and do not stop the assembly system
- Rather complex parts can be presented automatically
- Pallets occupy considerable space at the workstation
- The robot spends a lot of time slewing over to the pallet to get a part
- So you trade time for space: do you win?
Sony APOS - Palletizer

Image removed for copyright reasons.
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Sony APOS - Assembly Station

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Other Architectures

• Escort parts and tools (early Sony FX-1)
• Flexibility based on station lockout
  – one simple station per part or version thereof
  – assembly passes through unneeded stations
  – lots of floor space
• Roving robot (Hitachi, 1980)
  – carries assembly in its “lap”
  – visits stations that feed parts and hold special tools
• Roving robot teams (Denso, 2000)
  – Robots carry tools, assemblies ride conveyor, parts delivered at stations
  – Robots can be added or removed from system to adjust capacity
  – Robots can share work at highly loaded stations
• Parts made in or fastened to carrier strips - separates part prep from part feeding for higher feeding reliability
Sony Walkman II

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Source:
Sony Phenix 10 System

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Parts Tray

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Source:
Pallet Arrangement for Large Parts

- Bulk Parts for Several Assemblies
- Assembly Pallet
- Unique Parts for One Assembly
Starter Assembly Automation Line

(Slide from Denso)

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Making Stacks - Method 1

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Making Stacks - Method 2

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Making Stacks - Method 3

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AMP Ignitor

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Alternate Process One-handed

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Single Station System

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