Robot Introduction

Agenda

- Project Management for automated Systems & Machines
  - What to consider
  - Working intelligently with the systems
- The Overriding “Tenets of Automation”
  - Pose Control – Fixed Vs Flexible Automation
  - System Synchronization
  - System Balance
- The Robot as a System – by definition!
  - Manipulator
  - Power System
  - Controller Schemes
  - End of Arm Tooling
  - Sensors (environmental)

- Automation “Defined”:
  - Automation is the technology concerned with the application of complex mechanical, electronic and computer-based (computer-controlled) systems to the operation and control of production

Project Management for Automated Systems

- Automation includes:
  - Automatic Machine Tools, Forges and Sand and Permanent Molding machines for piece processing (CNC & DNC)
  - Material Handling Equipment (ASRS's, AGV's, Reactive Conveyors)
  - Automated Assembly Machines/systems
  - Process Controllers (PLC's)
  - Feedback Control Systems/System Sensors
  - Automated Data Collection Systems (AIDC)
  - Automated Data Reporting Systems (MRP)

Project Management for Automated Systems

- The development of an Automated System is a 4 step process:
  - System problem analysis for overall requirements
  - Determination of the systems special needs
  - Selection of and design of control hierarchy
  - Building/programming of individual components (Robots, Machines, AGV's, etc.)

Working Intelligently with a Production System – Design for Automation

- Does Variety (types) or Piece Count (volume) dominate?
  - Consider Fixed Automation vs. Flexible Automation
- Should we Consider Humans?
  - Typically, making it easier for automation makes it easier for humans (especially true for assembly)
- Cost Justification of the system
  - Consider Production Capabilities & Productivity Gains
  - Leads to Labor Replacement Savings
  - Consider Improved Quality, Repeatability & Reliability
  - Consider Quicker Changeovers/Improved Flexibility in Product development

Project Management for Automated Systems – what to consider

STEP 1

- Quantify Overall System Needs:
  - Number of Parts per hour (Production Rate!)
  - Product Variety and Part Size
  - Part Shape
  - Part Weight, etc

Project Management for Automated Systems – what to consider

STEP 2

- Find/Solve Special Needs Issues:
  - Robot Tooling and Machine Fixturing
  - Sensors for Pose Control or Decision-making
  - Communication Requirements (Machine to Machine)

Project Management for Automated Systems – what to consider

STEP 3

- Determine Control Hierarchy:
  - Isolated Actions
  - Master/Slave(s)
  - Event Driven Response – under higher or parallel control

Project Management for Automated Systems – Final Actions

STEP 4

- Build and/or Program *Individual Units*:
  - Robot Path Control
  - Machine Tool Codes
  - AGV Paths/Controls
  - ASRS Designs/Controls
  - Communication Network
  - Relays/Sensors, etc.

"Tenets of Automation" – Or what must be assured when Machines replace Humans

Pose Control is a principle that states that each degree of freedom of a machine, tool, product or process must be fully known or accounted for at all times for the (high quality) production systems to operate.

- ***A Degree of Freedom*** in the physical sense is:
  - One of a set of positional bits (X, Y or Z) or
  - One of a set of Rotational bits (Roll, Pitch or Yaw) so
  - ***Full POSE Control*** requires 6 dof from the machine!

“Tenets of Automation”

- ***System Synchronization*** (timing control) of operations must be maintained:
  - This requires that the sequence and timing of each movement during the process activity must be known and controlled.
  - This includes part counting, machine and product arrivals and departures, completed and closed communication sequences, etc.

“Tenets of Automation”

- ***System Balance***:
  - Each step in a process must be appropriately sized to complete its tasks within the overall system processing requirements.
  - Thus, no process should be slower/smaller (or faster/larger) than its predecessor or followers without accounting for product accumulation within the system.

Achieving Automation – Fixed vs Flexible

- In Fixed Automation Systems
  - POSE CONTROL is ***imposed*** by stops, cams, rotators, etc
  - SYNCHRONIZATION is controller by in-feed supply, part feeders, hoppers, pallet movers, etc
  - BALANCE is controlled by (Overall System) design

Achieving Automation – Fixed vs Flexible

- In Flexible Automation Systems
  - POSE CONTROL is achieve by sensing and adaptation by the machines to products in the system
  - SYNCHRONIZATION is assured by machine/system level adaptation to the changing needs of the feed stock and throughput demand
  - BALANCE is by designed over an extended time horizon, machines can be reprogrammed (on-line in Real Time) for changing part mix

Achieving Automation – Fixed vs Flexible

- Most Systems currently in use are HYBRIDS with elements of both Fixed and Flexible ideas!
  - Flexible Feed – Fixed POSE
  - Flexible POSE – Fixed Feed
  - Fixed Path-followers and Reprogrammable path-followers intermixed in the station, cell or line

The Robot is a System – by definition!

- Robots Institute of America: “A Robot is a REPROGRAMMABLE, MULTIFUNCTIONAL manipulator designed to move material, tools and specialized devices through variable programmed motions for the performance of a variety of tasks”
  - Note here: **RE-programmable,** that is an **AGILE,** machine that can be used for many different tasks (without full reconstruction)
- Stanford Research Institute International: “A robot is a general purpose machine SYSTEM that, like a human, can perform a variety of different tasks under conditions (*of time and space*) that may not be known *a priori*.
  - Note here: this implies a manipulator that ***May be Mobile*** and one that exhibits **Intelligence.**
  - This may be state of the art in the next 10 – 20 years!

The Robot System Contains 5 Major Sub-systems

- Manipulator
- Power System
- Control
- End-of-Arm Tooling
- Environmental Sensors

The Robot System

- The Manipulator
  - consists of joints (revolute or prismatic), actuators, and kinesthetic (positional) sensors
  - Types:
    - Cartesian
    - Cylindrical
    - Spherical
    - SCARA (selectively compliant assembly robots)
    - Articulating Arms

The Robot System

- The Power Systems
  - Pneumatic for light loads at elevated speed
  - Hydraulic for heavy loads or very high speeds
  - Electric Servo for general applications

The Robot System

- The Controllers
  - *Bang-Bang:* are mechanically programmed (movement to stops) and usually one-axis-at-a-time
  - *Point-to-point servo:* feedback of joints' positions as moves from point A to B are run – no control of the path between A and B (only end points are assured)
    - **G00** and **G11** or **G12** in **RC**
    - **JOINT** in **Karel** (Uses **$TERMTYPE** to effect rounding)
  - *Servo w/ Path Control:* the motion is controlled completely between point pairs including positions and orientation to follow desired space curves
    - **G01, G02, G03** in **RC**
    - **LINEAR** or **CIRCULAR** in **Karel**
  - *Autonomous Control:* Device control that allows paths to be determined in 'real time' as the devices moves and interprets various sets of sensory inputs to create 'intelligent' paths as it moves

The Robot System

- The End of Arm Tooling -- their complexity of task dictates the type of control scheme that is required
  - Grippers/Hands/spot welders
  - Sensor Arrays (static reading)
  - Sensors (active scanning)
  - Ladle/Hooks
  - Routers/Grinders/Drills
  - Spray Guns/Torches

The Robot System

- Environmental Sensors
  - devices that give higher level information for program control and or path planning

- Repeating, finally, Robots are Systems requiring design choices at 5 levels – mechanically, electronically and with computer integration!