Control Logic Requirements for Complex Manufacturing Systems

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Machine Tool Example

Stand Alone

Systems

High Volume Modular Machines

Machining Systems Solutions

Situation:

- Machine tools continually increase in sophistication, inherent flexibility, and user friendliness. All three factors provide added burdens to the controls systems, in particular the control logic and software.

Environmental Demands

- Sophistication
  - higher levels of diagnostics
  - remote diagnostic capability
  - prognostics (prediction)
  - re-start prompting
- Distributed controls
  - Multiple intelligent devices
- Multiple network support
  - Device level networks (CAN, PROF, etc.)
  - Ethernet

Environmental Demands

- Inherent flexibility
  - Multiple parts and part family support
  - Reconfigurability
  - Open architecture
    - NT platform
    - standardized APIs
  - Multiple programming languages
  - End user demands for
    - format
    - structure
    - modularity

Environmental Demands

- User friendliness
  - common look and feel
  - conversational statements
  - descriptive faults
  - “one-button re-start”
  - operational summary and root cause capture
  - fault tree descriptions

Situation:

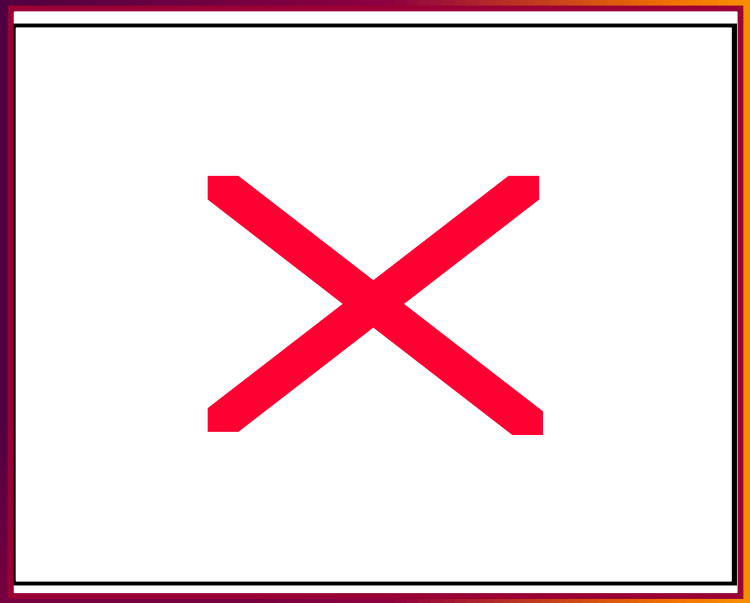
- Machine tools are expected to deliver higher machine availability today than in the past without adding to the machine cost. These operating considerations can be subdivided into functional demands. These demands are related to modes of control and autonomous operation

Functional Demands

- Automatic operation
- Manual and setup operation
- Recovery diagnostics
- Machine and personnel safety

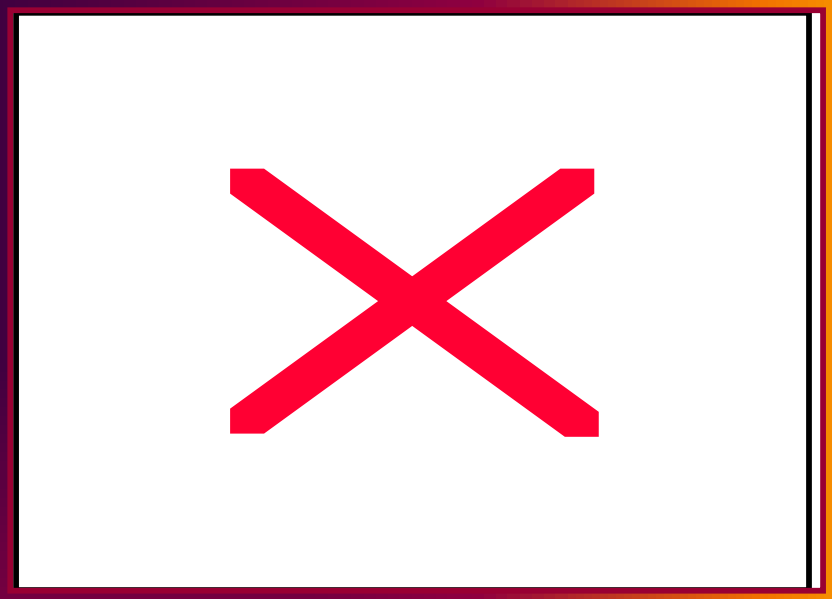
Functional Demands

- Automatic operation
  - untended operation within a specified and prove set of parameters
  - must handle without intervention all the part variations



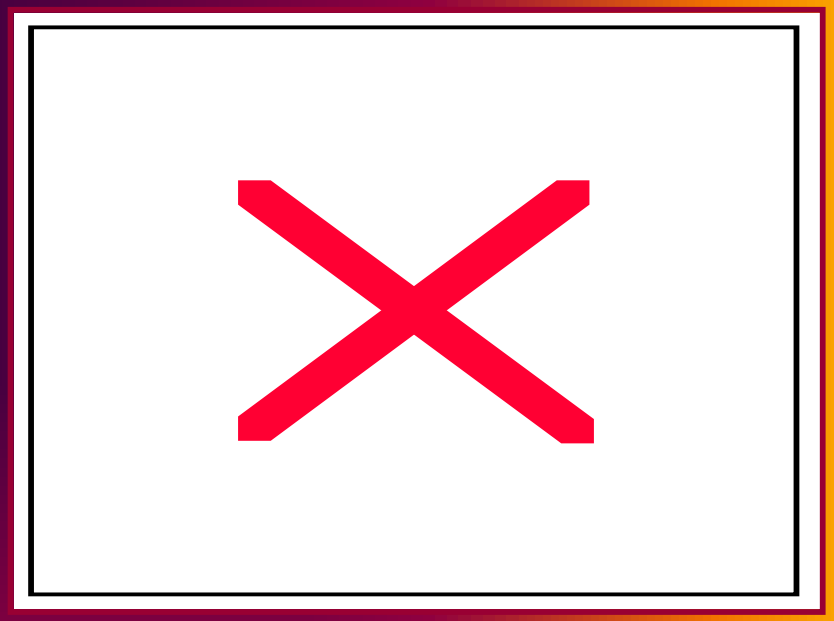
Functional Demands

- Manual and setup operations
  - Individual has control of a single entity and can operate it in almost any sequence
  - Typically used for set up, repair, and reconfiguration



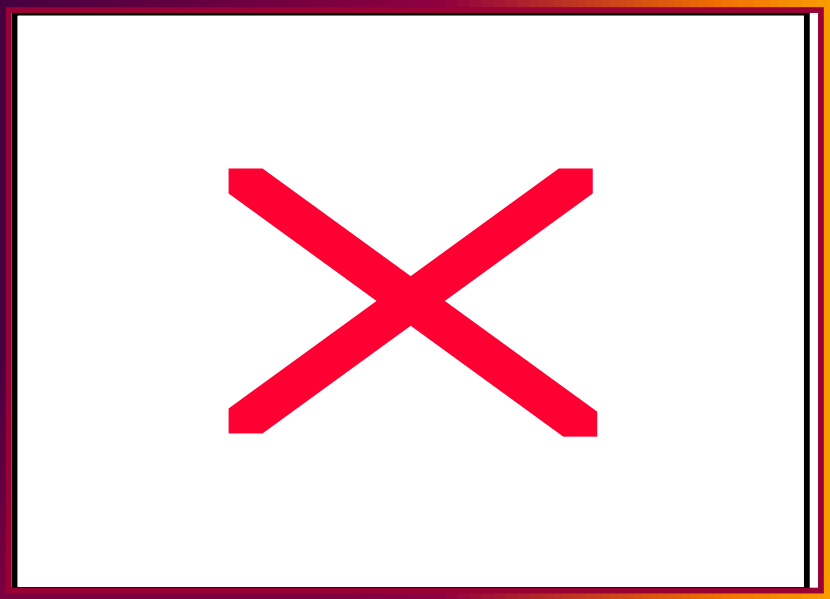
Functional Demands

- Recovery diagnostics
  - software directs operators and skilled trades to fault conditions
  - step through to the proper sequence
  - one-button re-start



Functional Demands

- Machine and personal safety
  - prevent unintended operation
  - prevent mechanical collision
  - during manual operation, ensure sequences do not create hazards or crashes



Software Complexity

Flexibility

Sophistication

User Friendliness

Environmental Demands

Software Complexity

Flexibility

User Friendliness

Environmental Demands

Sophistication

Machine and Personnel Safety

Automatic Operation

Functional Demands

Manual Operation

Recovery

Software Complexity

Flexibility

User Friendliness

Sophistication

Machine and Personnel Safety

Automatic Operation

Manual Operation

Recovery

Intelligent Device

Programming Language and Control Architecture

Hardware Platform

Environmental Demands

Functional Demands

Variables

Situation:

- Developing logic and software is complicated by variables that vary from project to project.

- These variables include the control architecture, intelligent devices, and the programming language which add complexity to the system design

Variables

- Programming Languages and Control Architecture
  - The executive software that the applications are embedded within
  - Controls architecture determines the focus of the software functions
- Examples:
  - Distributed vs. centralized control
  - Programming languages
    - Ladder
    - Flowchart
    - High level

Variables

- Hardware Platform
  - The manufacturers of control systems all choose to implement software functions differently
  - Planned obsolescence and upgrades burden software with “scope creep”
- Examples:
  - Allen-Bradley
  - GE Fanuc
  - Indramat
  - Temechanique
  - Siemens

Variables

- Intelligent devices:
  - Complex devices with their own on-board intelligence complicate interfacing requirements
  - Often devices require multiple programs to mirror the flexibility of the main system
  - No “see thru” capability between the main control and these devices
- Examples:
  - Servos
  - Robots
  - Gantries
  - CNCs

Summary

- Successful software design for machine tools requires tremendous skill. Incorporation of all the diverse requirements such
  - Environmental demands
  - Functional demands
  - and hardware/software variations
- Taxes even the most adept programmer
- Tools which can automate some or all of these tasks will be a welcome addition to the OEM repertoire