Design of Controls

Introduction
- Most machines require human control
- This control is achieved through a number of ways
  - Hand Controls & Foot Controls
  - Wheels
  - Pushbuttons
  - Levers
  - Data Entry Devices
    - Mice
    - Keyboards
    - Voice Controls

Design of Controls

Functions of Controls

Primary Function
- Transmit information to some device, mechanism or system

Two Types of Information Transmitted
- Discrete
  - High
  - Medium
  - Low
- Continuous
  - On-off
  - Boiler 1 - boiler 2 - boiler 3
  - Speed
  - Pressure
  - Cursor positioning on a VDT

Factors in Control Design

Factors affecting overall utility
- Ease of Identification
- Size
- Control-response ratio
- Resistance
- Lag
- Backlash
- Deadspace
- Location

Identification of Controls

Accidents occur due to misidentification of controls
- Airplanes
- Locomotives
- Automobiles

Identification is essentially a coding problem
- Primary coding methods:
  - Shape
  - Texture
  - Size
  - Color
  - Location
  - Labels
  - Operational Method

Generic Types of Controls

Classify by Two Variables:
- Types of Information Transmitted
  - Discrete
  - Continuous
- Force required to manipulate
  - Large
    - Direct mechanical linkage systems
  - Small
    - Electric and hydraulic systems

Identification of Controls

Discrimination of shape-coded controls
- Tactual Sensitivity
  - Air Force developed 15 knob designs which are discriminable from one another
  - 3 classes of knobs
    - Class A: Multiple Rotation
    - Class B: Fractional Rotation
    - Class C: Detent Positioning
- Knobs that have symbolic meaning are easier to recognize
Design of Controls

Identification of Controls

Texture coding of controls
- Three discriminable types
  - Smooth
  - Fluted
  - Knurled

Size coding of controls
- Minimum recommended size differences
  - 0.5 in. difference in diameter
  - 0.375 in. difference in thickness
- Concentric knob design

Identification of Controls

Color coding of controls
- Best when combined with another coding, such as size

Label coding of controls
- Extensive use as only coding is undesirable, but is also the minimum coding requirement

Auditory coding

Identification of Controls

Location coding of controls
- Accelerator vs. Brake location in automobiles

Operational method of coding controls
- Each control can only be activated by a unique operation

Discussion of coding methods
- Unique combinations of two or more codes
- Redundant coding - best when identification is critical
- Standardization, where possible, is ideal
- Vision restrictions limit to certain coding methods:
  - Shape
  - Size
  - Location
  - Texture
  - Operational Method

Resistance in Controls

Introduction
- Resistance is the principle contributor of "feel" to a control
- Two forms of control manipulation
  - Amount of displacement
  - Amount of force applied

Resistance in Controls

These are the primary sources of control feedback
- Three types of controls:
  - Pure displacement, free-position, or isotonic controls
  - Pure force, or isometric controls
  - Combination controls
Design of Controls

Resistance in Controls

- The best form is a combination of the two types
- Pure force controls are superior to a combination when used with higher-order tracking control systems to track a relatively fast moving, gyrating target

Types of Resistance

- All controls except pure displacement controls have resistance
- Primary types of resistance
  - Elastic resistance - proportional to displacement
  - Static friction - initial resistance to the beginning of motion
  - Coulomb friction - resistance to motion
  - Viscous damping - proportional to velocity
  - Inertia - proportional to acceleration

Resistance in Controls

- Combining Resistances:
  - Elastic resistance alone is the best situation
  - Adding inertia always results in a decrement in performance
  - The worst situation is elastic and inertial resistances

Deadspace

- Deadspace is the movement around the null position that results in no movement of the device being controlled
- Deadspace in any amount usually has an effect, but has a greater effect in highly sensitive systems
- Increase of deadspace results in a linear increase of time needed to acquire a target
- Deadspace may be more detrimental with compensatory tracking systems than with pursuit systems

Backlash

- Backlash is essentially deadspace at any control position (i.e. not just around the null position)
- Typically, operators do not cope well with backlash
- Variation in backlash and variation in Gain results in the conclusion that increasing backlash is detrimental, but is most detrimental at high levels of gain
- Therefore, if the backlash cannot be reduced, the gain of the system should be lowered to compensate

Design of Specific Hand-Operated Controls

Cranks and Handwheels

- Different jobs require different designs
- Figure 11-11 demonstrates that 7 inches was the best of the three sizes tested

Knobs for Producing Torque

- Multiple criteria need to be considered, for example the best design for torque caused discomfort due to its shape
Design of Controls

Stick-Type Controls
- The best length is about 18 in, but that gain was more important
- The best design tended to be a first order spring-return

Multifunction Hand Controls
- The following principles should be followed:
  (1) The operator should not have to observe the control to operate it
  (2) The hand should remain in contact with the control throughout the task
  (3) Auxiliary controls should be accessible

Design of Specific Hand-Operated Controls

Foot Controls

Introduction
- Hand controls more prevalent than foot controls
- Foot controls often restrict posture
- The following design parameters should be considered:
  • Do controls require thrust with or without ankle action
  • The location of the fulcrum of a hinged pedal
  • The angle of the foot to the tibia bone of the leg
  • The load required
  • The placement of the control relative to the user

Foot Controls

Pedal Design Considerations
- There have not been any conclusive design solutions
  • Foot Controls for Discrete Control Action
  • Forward motion is slightly faster than backward motion, but it is not significant
  • Use Drury’s index of task difficulty, to find the Reciprocal Movement Time and then to find the Single Movement Time

Foot Controls

• They are the most common foot controls
• Movement time is shorter when the pedals are on the same level, but errors are more common with coplanar pedals