Northern Illinois University

Dekalb, IL

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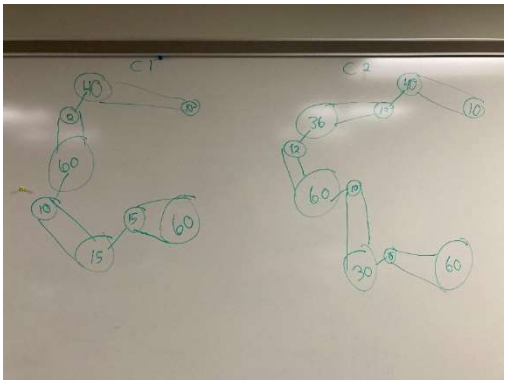
Initial Project Plan - Crazy clock Effect for 2022 Stage Machine Design Competition

Overview

Analyze and create a mechanism to provide motion for the “Crazy Clock” effect, choose the correct actuator to drive the mechanism, design a housing, and create an HMI to accommodate the demands of the effect.

Clock Mechanism Analysis



Establish a base knowledge of mechanical processes and define the type of motion (rotary versus linear) required for the effect.

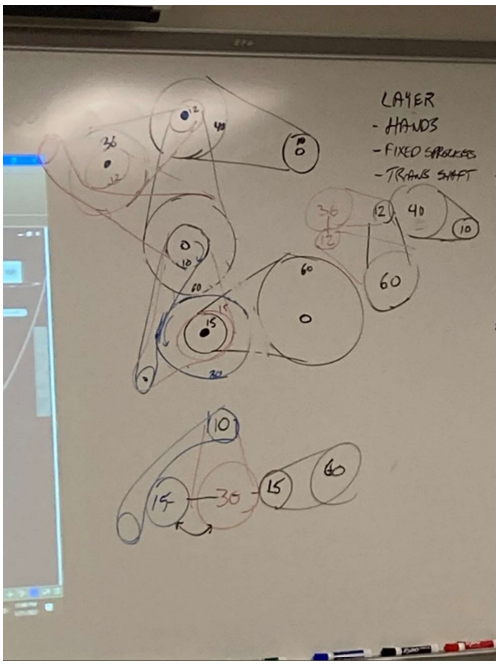
Analyze rotary motion for the individual hands on the face of the clock and relationships between second, minute, and hour hands for each condition defined by the effect.

Develop comparative relationships between clock “hand” shafts for each condition and select gears/sprockets to achieve desired relationships.

Considerations:

- Relative tooth counts to find mechanical relationships between sprockets
- The direction of the hands must switch between movement sessions - sprockets with parallel tangent belts spin the same direction, opposing tangent belts to spin in opposite direction, and gears that make contact spin in opposite direction
- Where possible, sprockets on the same shaft should have the same shaft diameter, but as different tooth count sprockets have different shaft diameters, this is not a huge issue because we have a giant metal lathe at our disposal.
- Analyzed the best practices for transitions between the two conditions, discussed transmission versus changing out sprockets. We decided to pursue sprockets because of the simpler design.

Sprocket considerations:



- Sprockets will fit behind form factor of clock face
- Highest and lowest manufactured tooth count
- Available tooth counts of given sprocket families
- Cost for all sprockets and belts
- Shaft diameters
- Material of belt and sprockets
- Light Weight for portability
- Selecting sprockets that will stay quiet

Housing considerations:

- Shafts must connect to back and remain stable during rotation
- Face must be solid to accept artwork for face
- Circular shape of design/solid material
- CNC Water Jet Cut for hole accuracy between multiple plates
- Need feet to prevent clock face from rolling
- Open for access to gears for the transition between conditions
- Handles to help carry the clock
- Guards for safety

Actuator Analysis

Determine RPM of each shaft in each condition.

Determine Max RPM of output shaft of readily available actuator.

Decide which hand shaft to connect to actuator and tooth count to obtain desired hand speeds from actuator.

Uses a VFD for maximum control.

Verify available power at Purdue to operate actuator.

Human-Machine Interface Analysis

Determine requirements for HMI

- Choice of direction - Yes
- Adjustable speed - Yes
- Position control – Not necessary
- Programmable vs Hard-wired – Programmable preferred
- Sustained or Hold to Run – Hold to Run preferred due to RA/RR concerns about speed of hands and mechanism.
- E-Stop required – Desired but not required. RA/RR determines low risk if effect is not accessible by persons

Create a Project Schedule

Select sprocket family, sprocket tooth counts, belt sizes, and count of blocks and shaft collars

Place order with MMC

Select actuator and design interface with mechanism

Design housing to accommodate actuators and mechanism

Draft plates for housing and hands

Cut materials

Assemble housing

Populate housing with shafts and gears and ensure that mechanism performs as designed

Design and assemble HMI

Connect actuator to drive system and program HMI to established parameters

Populate housing with actuator and attach to mechanism

Test system, analyze for issues, including excessive noise and systemic functionality

Disassemble for transport, reassemble, and test again.

Disassemble and pack for transport.