MAKING MODERN LIVING POSSIBLE

Danfoss Turbocor
Magnet Insertion Process

Team 5

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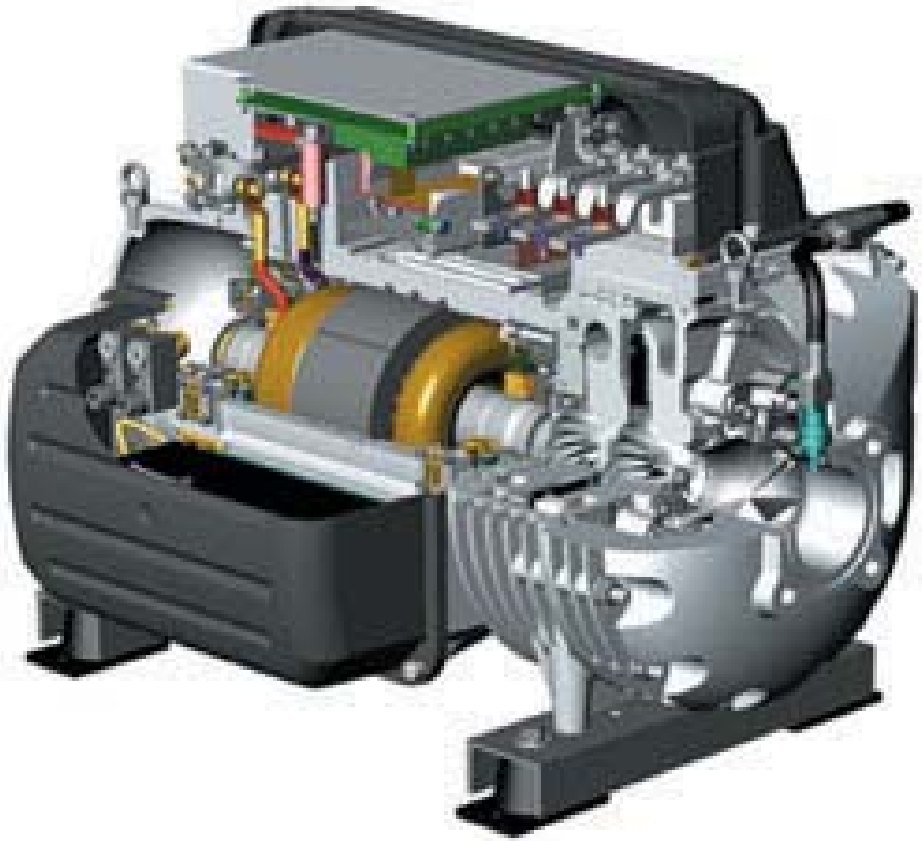
Background

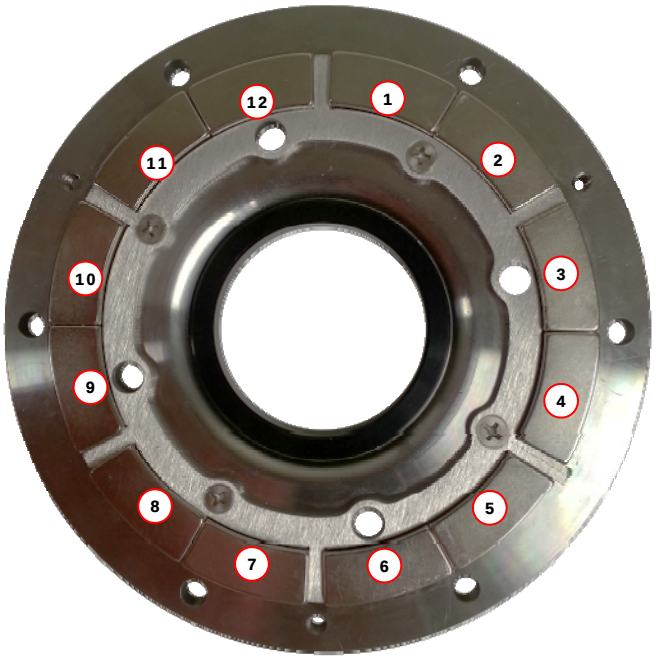
- Pioneer and world leader of the oil-free centrifugal compressor
- World's most efficient commercial refrigerant compressors
- World's first totally oil-free compressor
  - Magnetic bearings result in a levitated rotating shaft



Bearings and Magnet Overview

- The three different bearings are named:
  - Big
  - Small
  - Twin
- Used in different model compressors designed for specific applications and operations
- Two different magnets used in the bearing's design:
  - The shorter magnet is used on the "big" and "twin" bearings
  - The longer magnet is used on the "small" bearing
  - The red dot is to identify the orientation of the magnet

“Big”

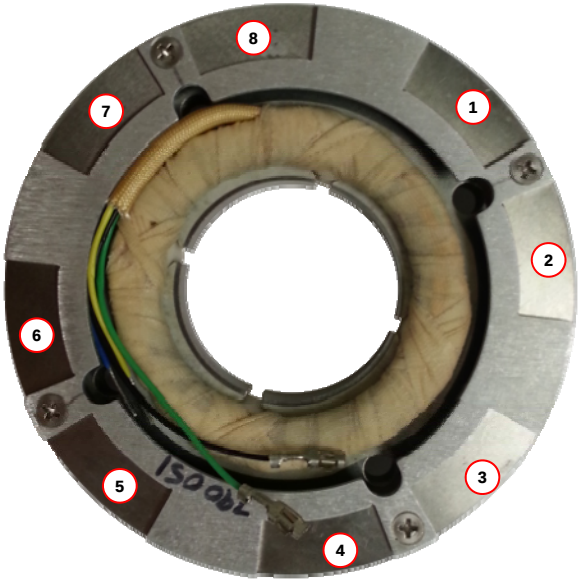


- Largest bearing outer diameter (6.37 inches)
- 12 magnets in 6 pairs
  - 6 spacer regions separating magnets
- Magnets pairs are separated evenly by 60 degrees
- 4 coolant holes
- Uses short magnet design

“Small”

- Bearing outer diameter (5.38 inches)
- 8 magnets in 4 pairs
  - 4 spacer regions separating magnets
- Magnets pairs are separated evenly by 90 degrees
- 4 coolant holes
- Uses long magnet design

“Twin”



- Bearing outer diameter (5.38 inches)
- 8 magnets
- Magnets are not separated evenly due to spacer geometry
- 4 coolant holes
- Uses short magnet design

Bearing Compatibility

Big

- 12 magnets to insert
- 60° spacer

- Magnets in pairs
- Even spacer separation

Small

- 120° spacer
- Longer magnet design

4 coolant holes in same location

Short magnet design

8 magnets to insert

Uneven spacer geometry

Twin

Current Magnet Insertion Issues

- Existing automated assembly machine is not reliable
  - Control issues
  - Magnet spacer rejection causes jamming
- Currently assembled by hand by a technician
  - Ergonomic issues due to strong magnetic forces
    - High impacts cause magnets to fracture
  - Proper magnet placement
    - Magnet misalignment causes bearing assembly failure
  - Proper magnetic pole orientation
    - Improper orientation causes compressor to fail

Project Path

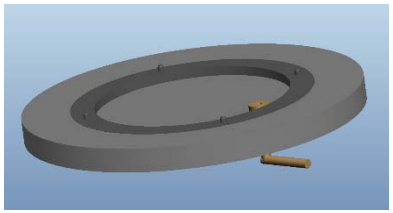
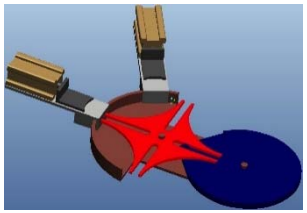
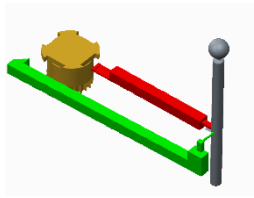
- Reparation of existing automated machine
  - Pros: Safe & design has already been developed
  - Cons: Lots of electronics, controls, & sensors

- Develop a simple insertion mechanism
  - Pros: New & improved
  - Cons: Requires new design & increases cost

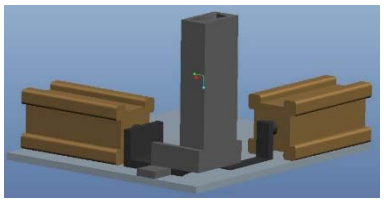
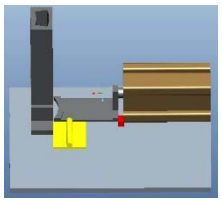
- Develop a handheld tool to aid insertion process
  - Pros: Simple & cost effective
  - Cons: Little improvement

Project Path

- Develop a simple insertion mechanism
- Two main issues with selected path:
  - 1. Rotating the bearings to specific magnet location.
    - 3 models:

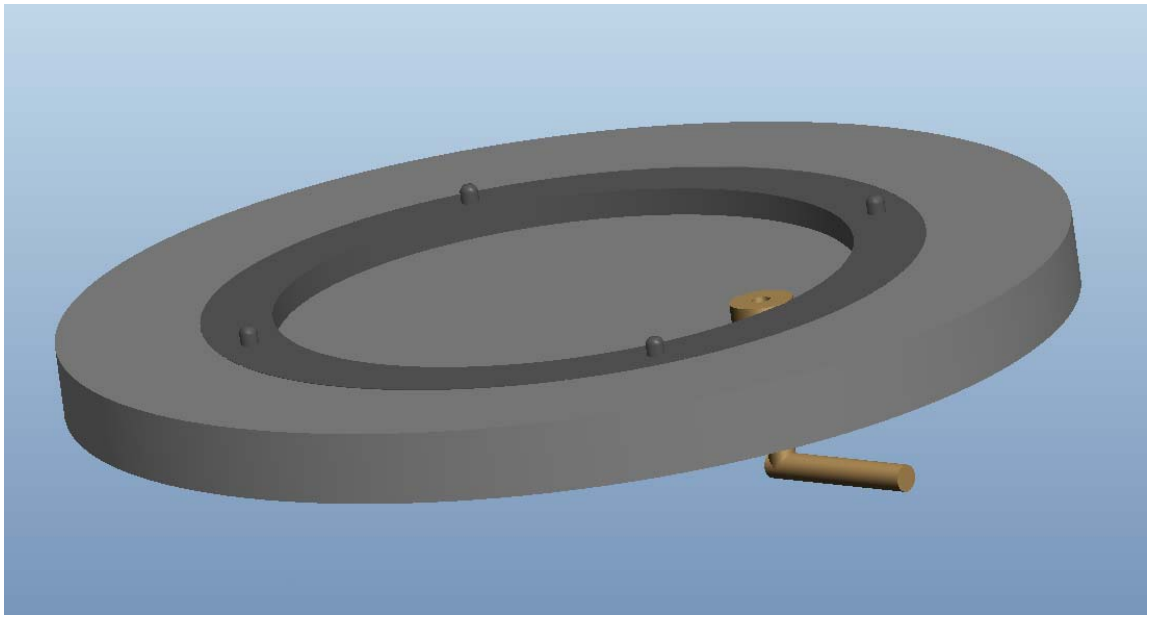




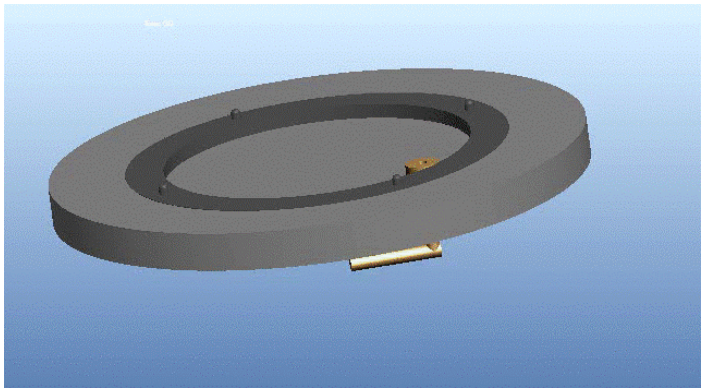
  - 2. Inserting the magnets.
    - 2 models:

Rotary Indexing Prototype #1

Internal Gear-set with Crank





Pros:

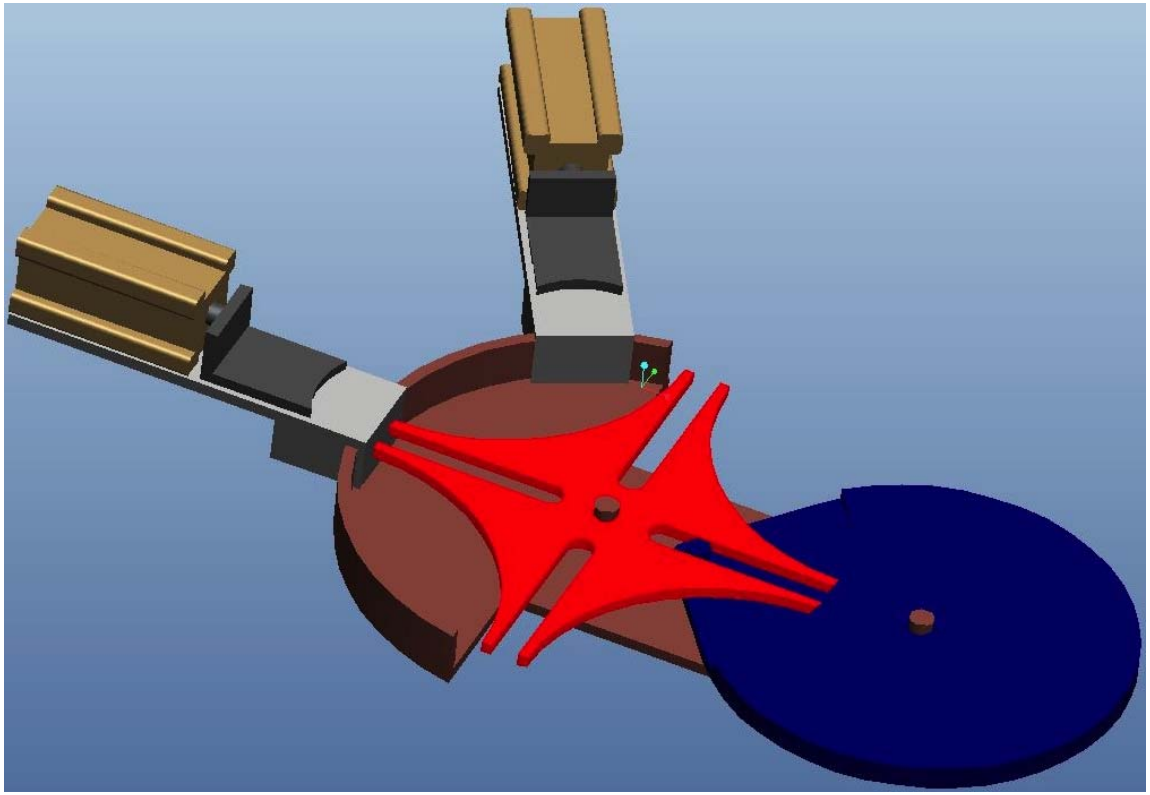
- Simple design
- Adaptable to all bearing sizes
- Possible conversion to an automated mechanism

Cons:

- Safety
- Large rotational input
- Actuator triggered by hand

Rotary Indexing Prototype #2

Dual Actuator Geneva Wheel



Pros:

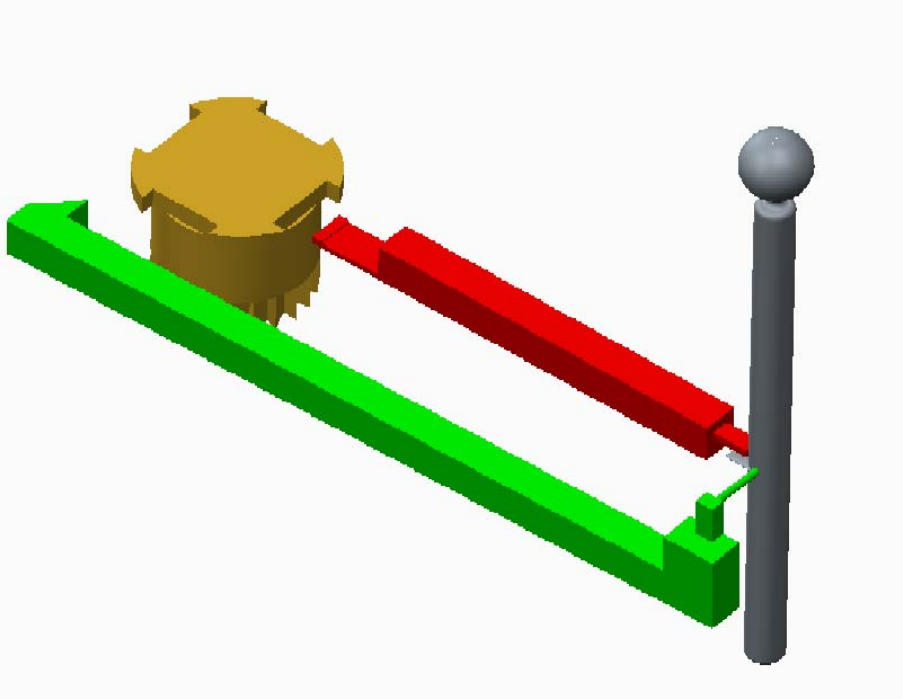
- Works for bearings with same number of magnets
- Simple design
- Possible conversion to an automated mechanism

Cons:

- Two linear actuators
- Cost
- Requires user to input preset conditions before use

Rotary Indexing Prototype #3

Indexing Lever Arm



Pros:

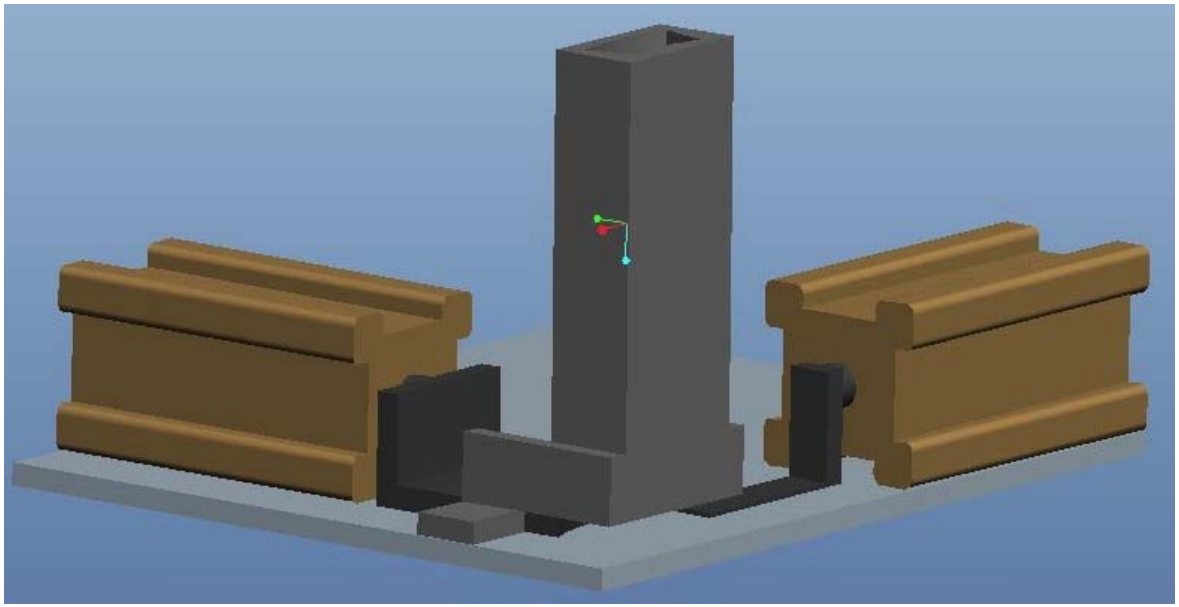
- Cost
- Simple design
- Single input
- Does not require any linear actuators

Cons:

- Each bearing requires a separate mechanism

Inserting Mechanism Prototype #1

Double Action Magnet Inserter



Pros:

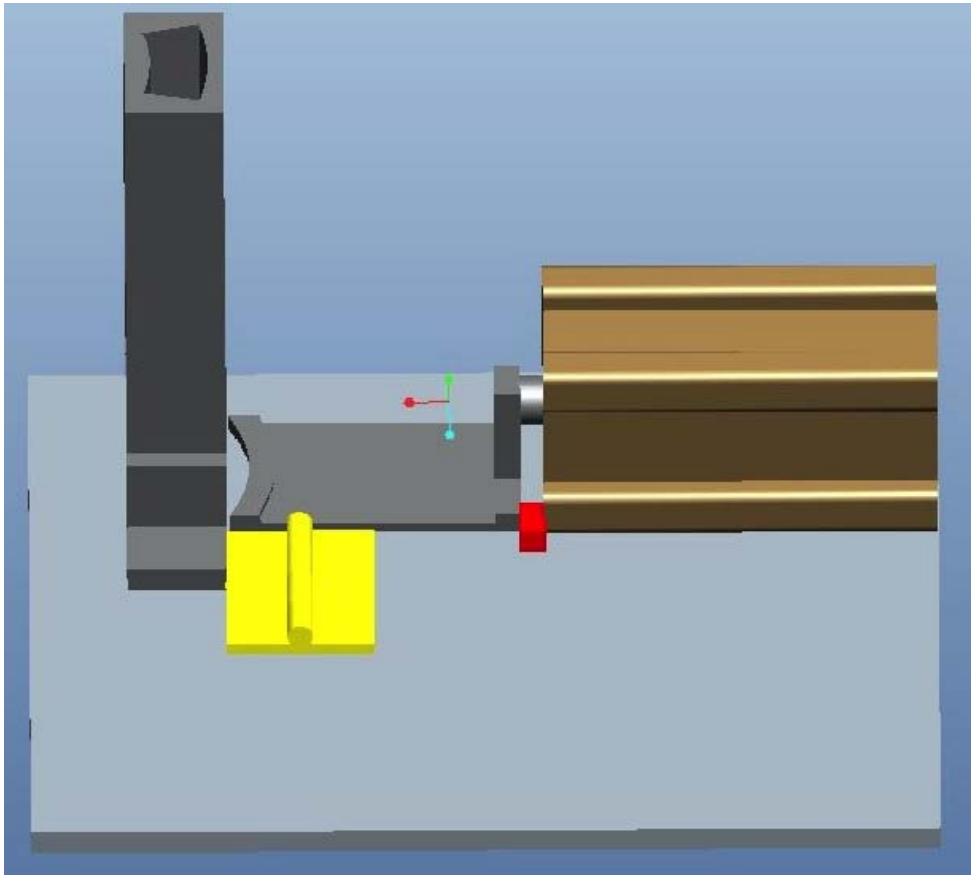
- Simple design
  - Used by existing faulty automated machine

Cons:

- Two linear actuators
- Cost
- Size

Inserting Mechanism Prototype #2

Single Action Magnet Inserter



Pros:

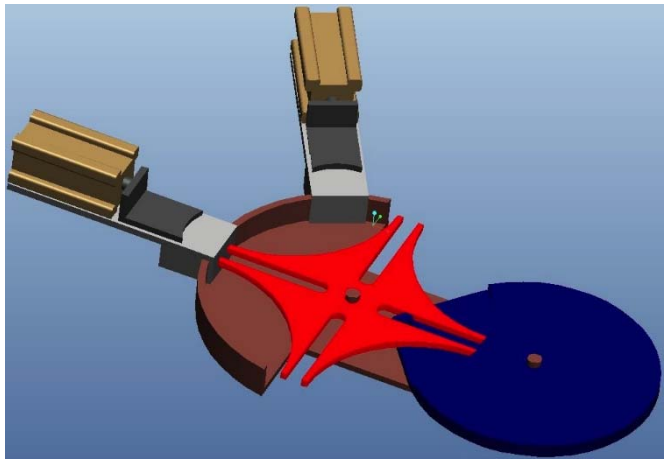
- Single linear actuator
- Compact

Cons:

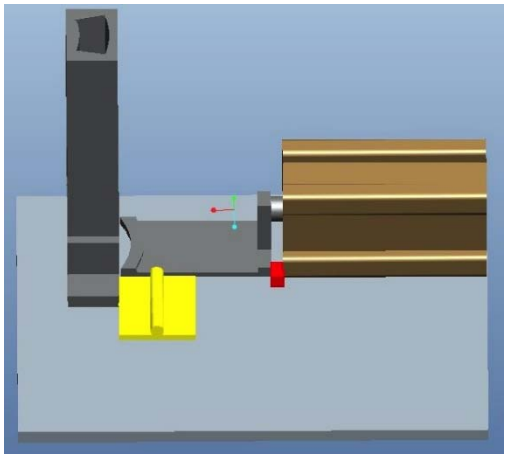
- Reliability

Concept Selection

- Rotary Indexing Mechanism
  - Dual Actuator Geneva Wheel
    - Simple for technician to set up and run
    - Allows possibility to integrate switches for automation
    - Will have to design for changing Geneva wheels for each bearing

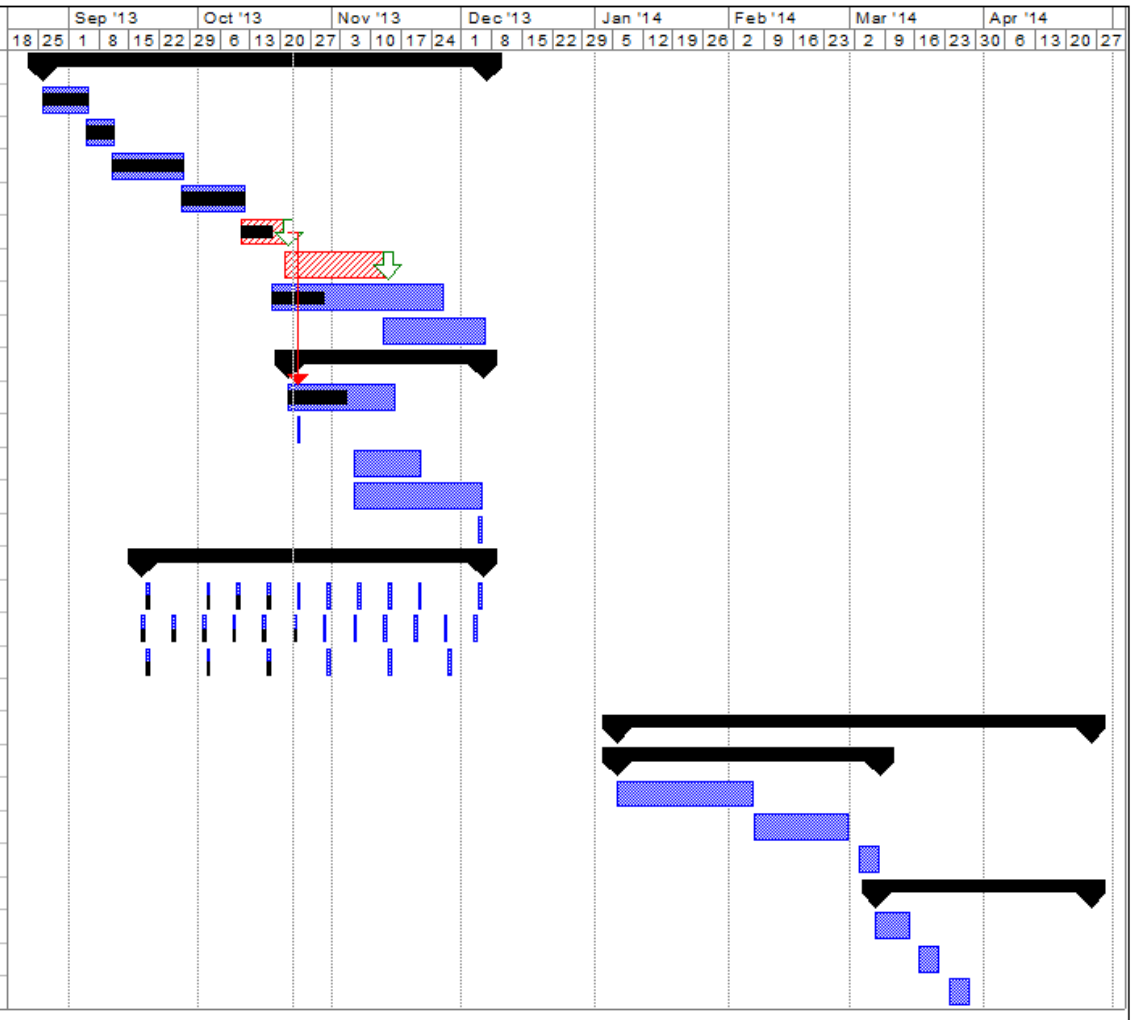


- Magnet Inserting Mechanism
  - Single Action Magnet Inserter was chosen
    - Lower cost
    - More compact



Gantt Chart

ID	Task Name
1	**Senior Design Deliverables**
2	Code of Conduct
3	Ice Breaking Project
4	Needs Assessment
5	Project Plans and Product Specification
6	Concept Development Presentation
7	Interim Design
8	Design Webpage
9	Final Presentation for Fall Semester
10	**Detailed Design**
11	3D Modeling
12	Design Review
13	Drawing Development
14	Procurement
15	Submit Final Drawings to Turbocor
16	**Meetings**
17	**Turbocor**
28	**Mentor Meetings**
41	**Staff Meetings**
48	
49	**Spring Tenative Timeline**
50	**Fabrication/Assembly**
51	Machining Parts
52	Assembly
53	Pneumatics
54	**Validation**
55	Tuning and Setup
56	Testing
57	Rework



References

- *Danfoss turbocor*. (n.d.). Retrieved from http://www.turbocor.com

- [Web log message]. (2011, February 07). Retrieved from http://mechanicaldatahelp.wordpress.com/2011/02/07/20-geneva-mechanisms/

Questions?