MAKING MODERN LIVING POSSIBLE

Danfoss Turbocor
Magnet Insertion Process

Team 5

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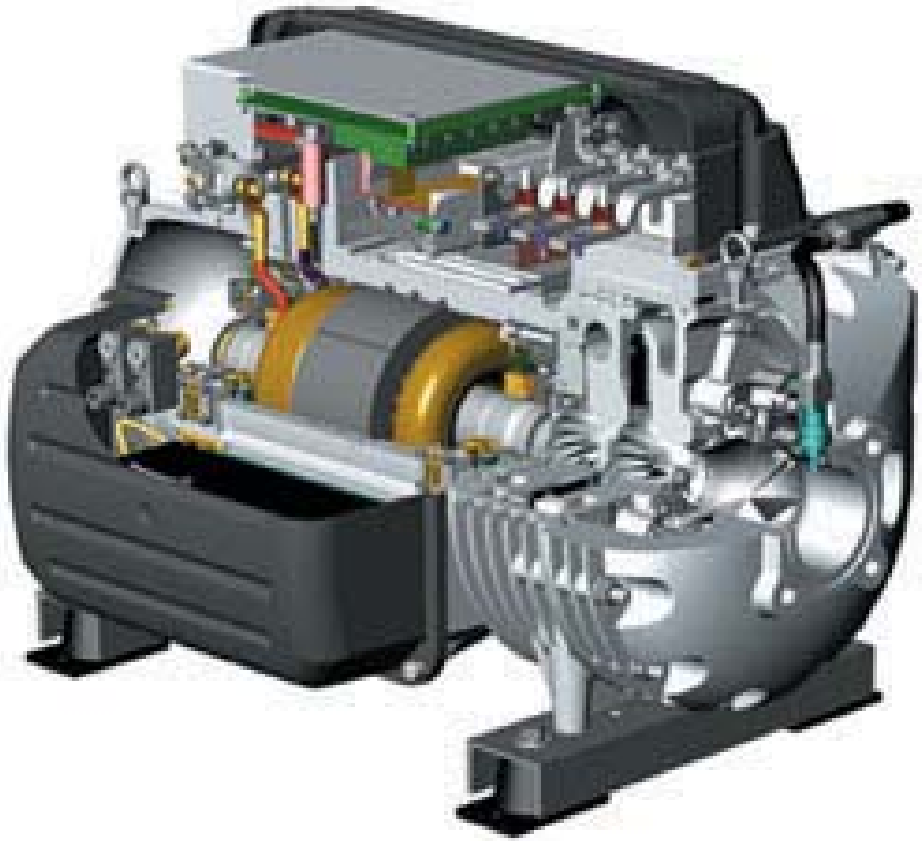
Team Leader:	Jaro Volny
Coordinator/Financial Advisor:	Henry Ferree
Webmaster:	Timothy Blum
Mentor:	Dr. Simone Hruda
Liaison Engineer:	Paul Lulgjuraj

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



Brief Review

- Problem Statement:
  - “There is a need for an ergonomic and efficient magnet insertion process for properly placing magnets on axial bearings.”
- Project Scope:
  - Currently a technician inserts the magnets manually
  - Issues with quality, operator fatigue, operator downtime
  - There is an existing insertion machine, currently not in operation due to many issues

Bearing Compatibility

Big

- 12 magnets to insert
- 60° spacer

- Magnets in pairs
- Even spacer separation
- North up orientation

Small

- 90° spacer
- Longer magnet design

4 coolant holes in same location

Short magnet design

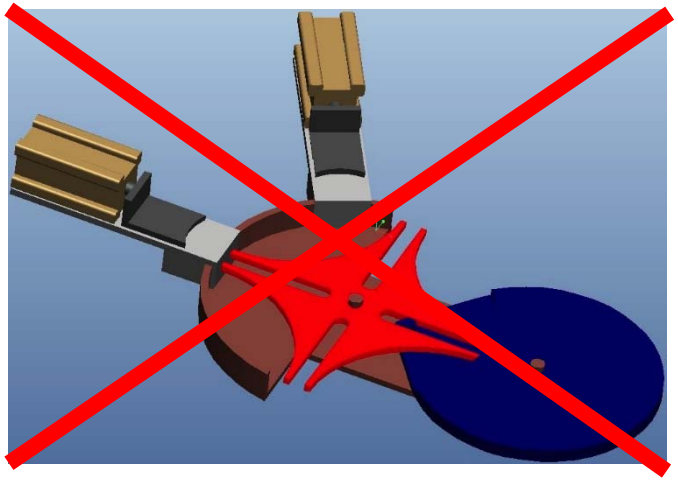
8 magnets to insert

- Uneven spacer geometry
- South up orientation

Twin

Original Selection and Changes

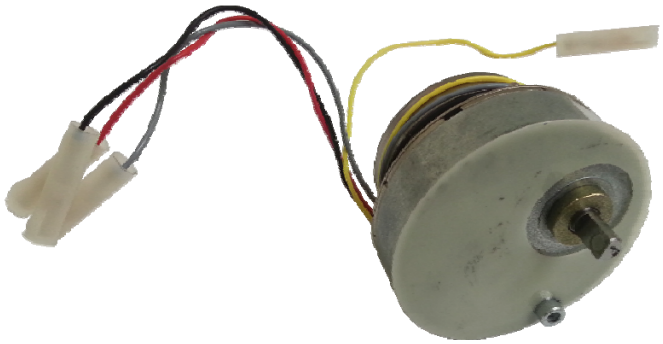
- First selected design:



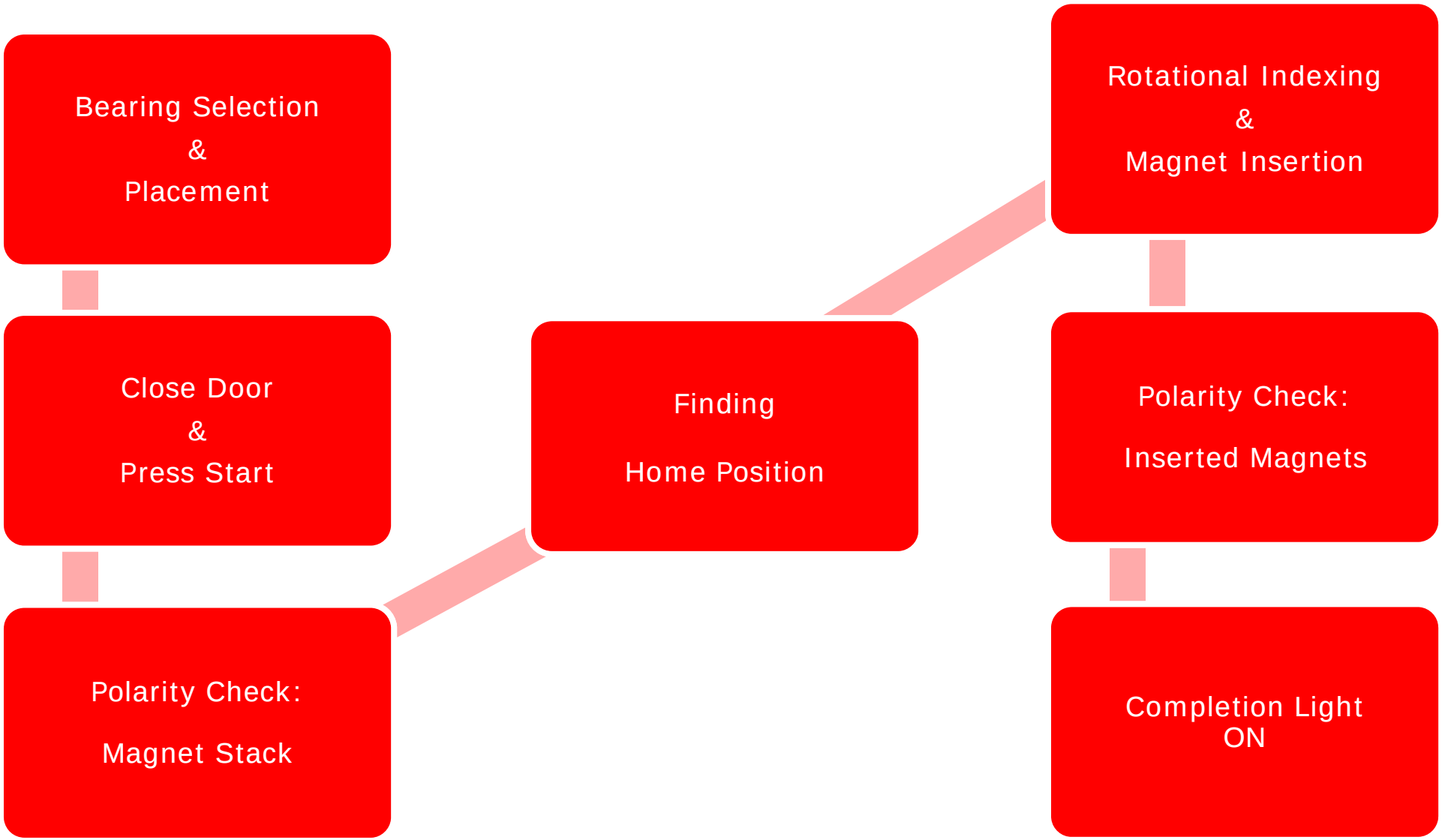
- Turbocor issues with design:
  - Mechanical system cannot accommodate for bearing geometry changes
  - Turbocor is always evaluating design changes to improve compressors
  - Suggested use of a stepper motor

Final Selected Design

- Combination of 2 project paths:
  - 1. Creating a simple insertion mechanism
  - 2. Repair of existing automated magnet insertion machine
- Rotary indexing of bearing accomplished by stepper motor
- Inserting magnets accomplished by pneumatic actuators
- Many details to consider to construct this system
  - Safety
  - System ergonomics
  - Sensors
  - Logic board
  - Pneumatics
  - Material Wear
  - Assembly



Basic Operational Flow



Sensors

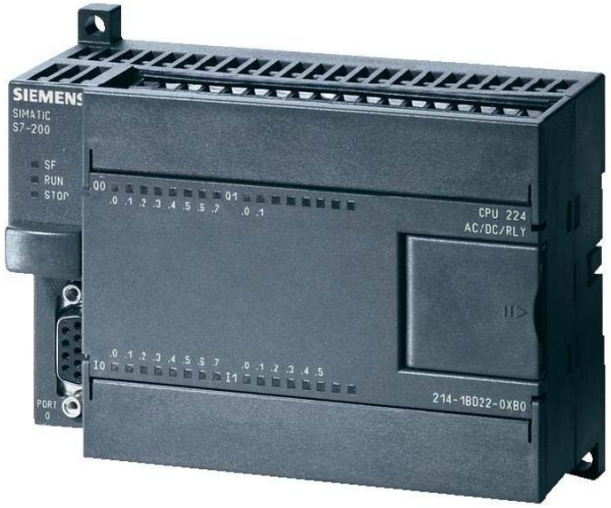
- 10 sensors:
  - 6 proximity sensors:
    - 3 to detect nests
    - 2 to identify actuator retraction
    - 1 for door open/close status
  - 3 magnetic polarity checker sensors:
    - 2 to detect magnet stack polarity
    - 1 to detect inserted magnet polarity
  - 1 magnetic sensor:
    - Finding home position

Buttons/Switches/LED's

- 2 buttons:
  - Start
  - Emergency shutoff
- Triple throw switch:
  - Magnet insertion
  - Polarity check
  - Fully automated
- 4 LED's
  - Error
  - Complete
  - 2 empty magnet stack indicators

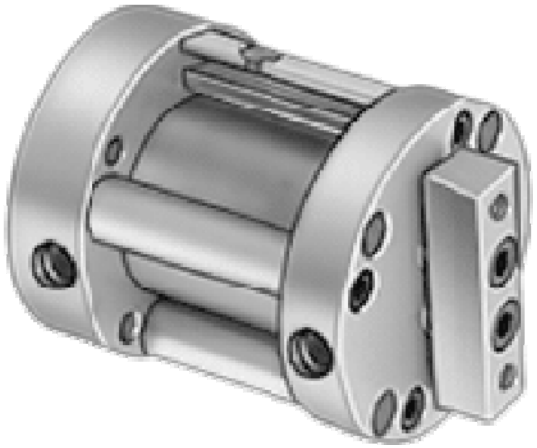
Programmable Logic Controller

- Siemens S7-200 series
  - CPU 224XP
    - 14 digital & 2 analog inputs
    - 10 digital & 1 analog outputs
    - 7 expansion module capability
  - 8 channel analog input module
  - Position module
- Mounted on Din Rail
- Programmed using Ladder Logic

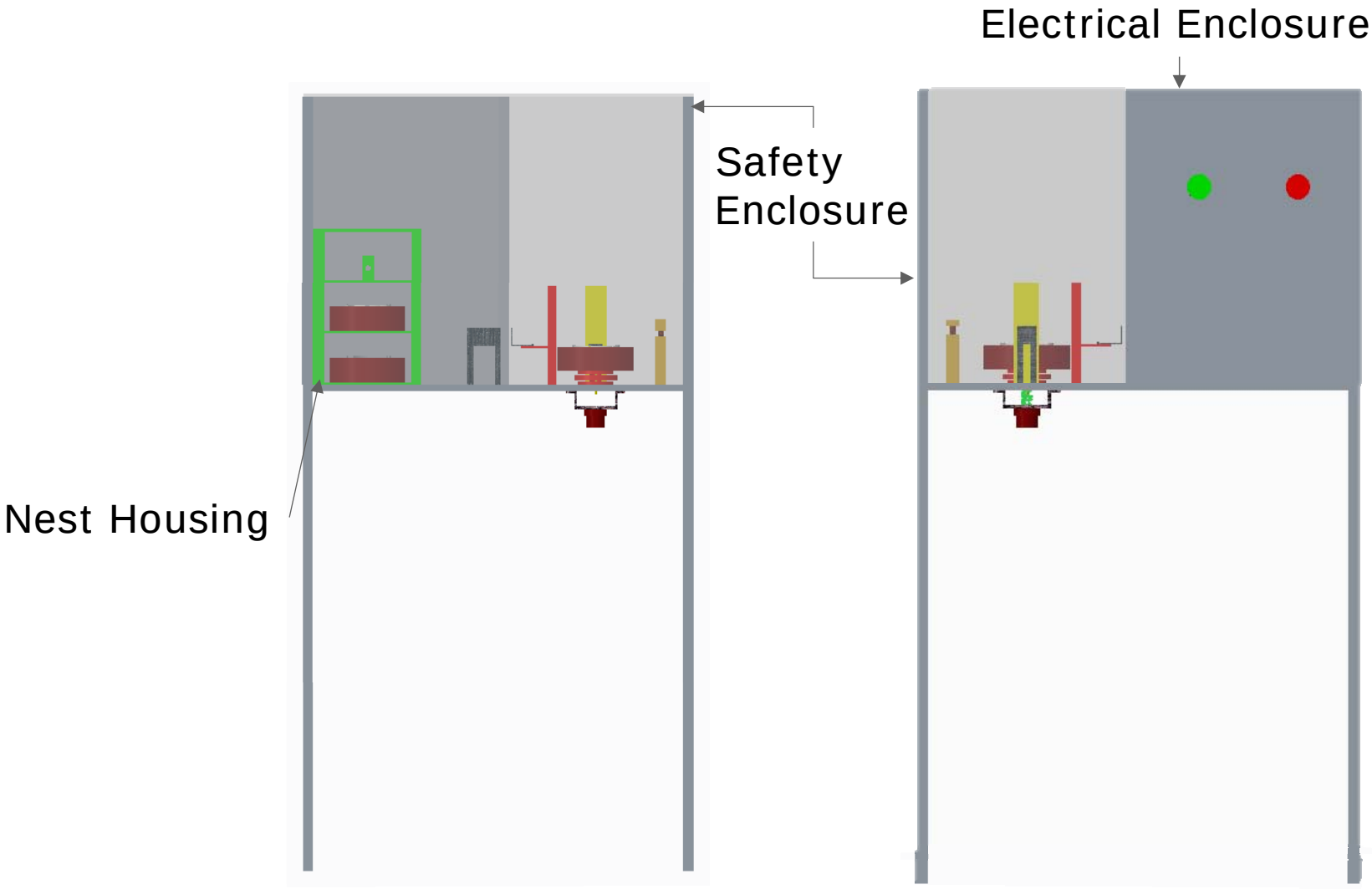


Actuators & Pneumatic Accessories

- Nonrotating pancake aluminum tie rod air cylinder
  - 38 pound force @ 100 psi
  - Nonrotating
  - Switch ready
  - 4” stroke length
  - Double action
- Pressure regulator valves
- Air hoses & connections
- Air blow-off nozzles



Assembly



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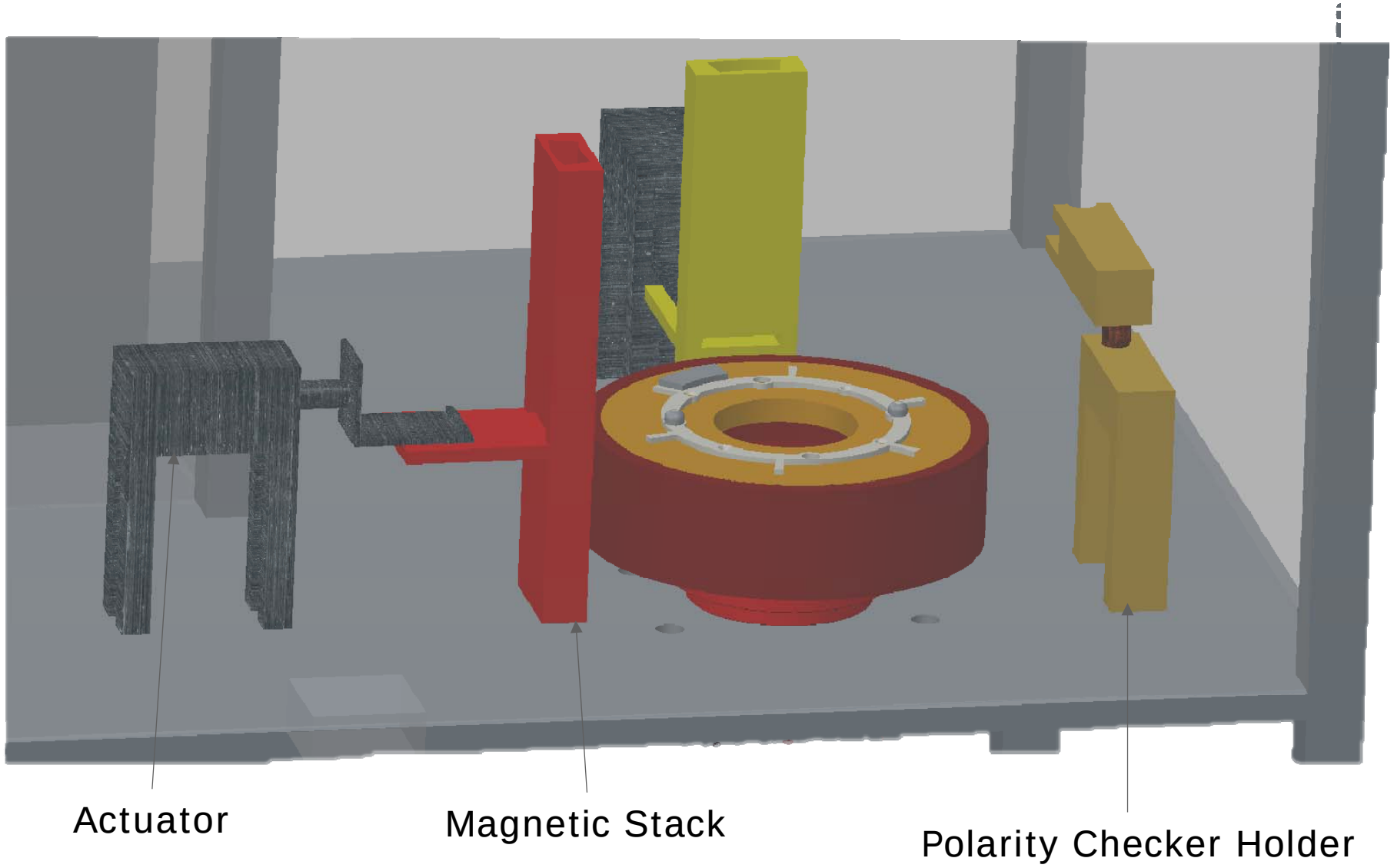

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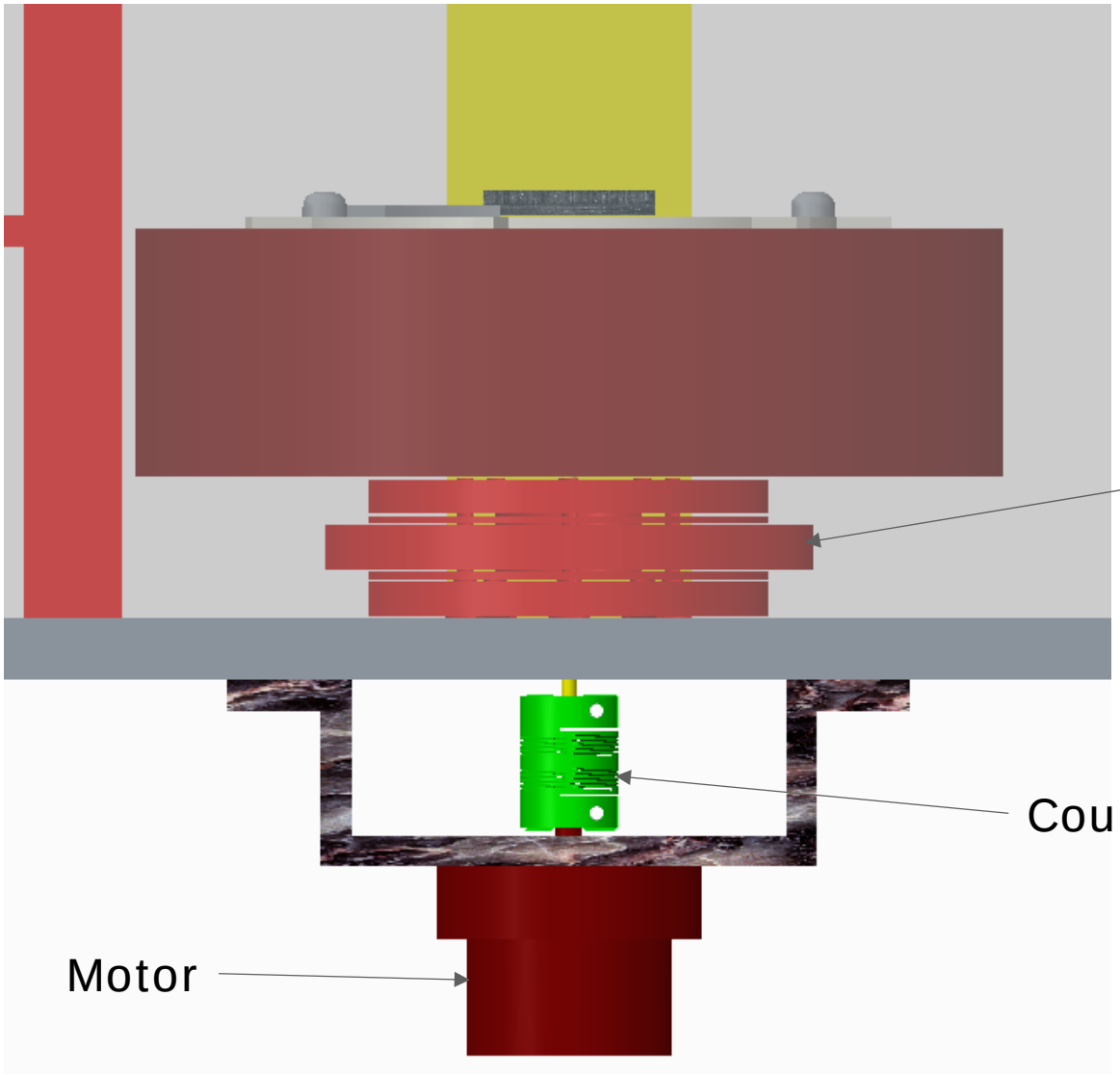


Bill of Materials, Cost and Procurement

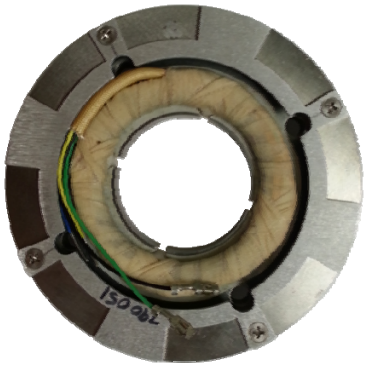
#	Item	Quantity	Price	Vendor
1	Aluminum Baseplate	1	$335.83	McMaster Carr
2	Plain Bearing Turntable	1	$215.27	McMaster Carr
3	Flexible Coupling	2	$71.48	McMaster Carr
4	Nest Material	2	$398.04	McMaster Carr
5	Power Supply	1	$63.50	Automation Direct
6	Actuators	2	$143.60	McMaster Carr
7	Magnet Stack Material	1	$6.91	McMaster Carr
8	Sensors	12		
	Proximity Sensor	8	$32.56	Digikey
	Magnetic Sensor	1	$61.61	Mouser
	Polarity Checker	3	$300.00	Unknown
9	Wiring/Electronics	1	$40.00	Unknown
10	Dinrail Mount	2	$50.00	Grainger
11	80/20	1	$164.40	8020
12	80/20 Acrylic	2	$300.00	8020
	In House			
13	Machining Hours	16	$640.00	Turbocor
14	Motor	1	$30.00	Turbocor
15	Pneumatic Equipment	1	$50.00	Turbocor
16	Mounting	1	$5.00	Turbocor
17	Electrical Cabinet Housing	1	$60.00	Turbocor

Total	$2,968.20
Actual Total	$2,183.20

- Interim estimate of cost of full insertion machine
- Some costs are included that are covered by Turbocor
- This benefit reduces the overall cost
- Budget: $2000
- Bottom line cost could reduce:
  - Shipping discounts on bulk orders,
  - Turbocor discounts with suppliers

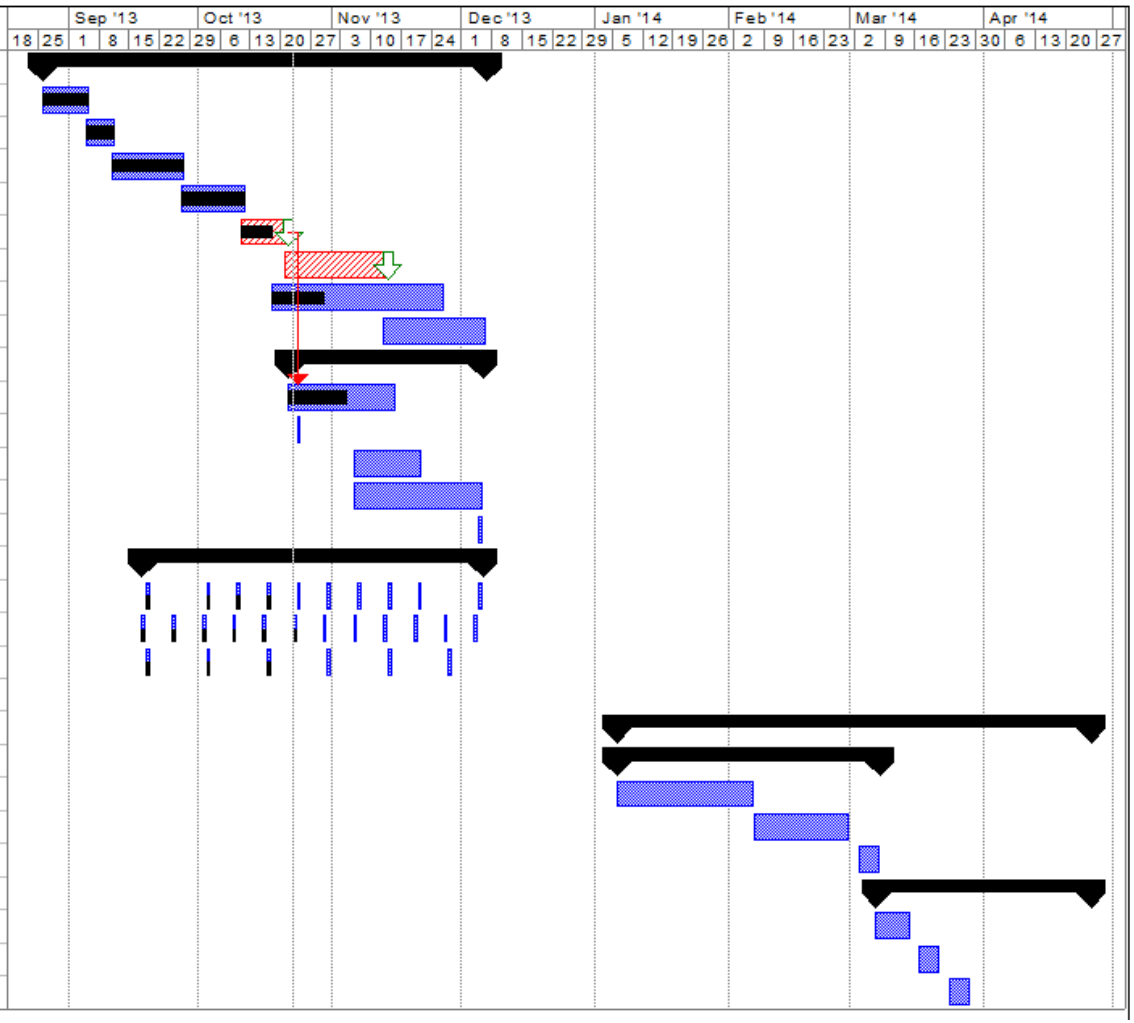
Future Work

- Purchase Materials & Parts
  - Cast Aluminum
    - Baseplate
    - Other machined parts
  - Sensors
  - Buttons
  - Bearing
  - Logic controller
  - Actuators
  - Power supply
  - Electronic & Pneumatic connections
  - 80/20
  - Polycarbonate
- Finalize CAD drawings



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?