# Problem Definition

## Problem Description

Doepker Industries is looking into transitioning its rotator units which are currently hydraulic powered and hand cranked to units which operate on electrical power. This would bring many benefits to Doepker Industries, the main benefits being that it will help increase production output while maintaining quality standards, and be safer to operate than the current rotators.

Doepker Industries requests a design for a rotator by December 6, 2019 which can be used to rotate equipment for welding, blasting, painting, or finishing that can be mounted to their existing rotator frames. The design is required to be capable of rotating a 1000lb load to any degree, with the ability to automatically rotate the load to pre-defined angled positions. This rotator will help by allowing operators to work with equipment at a comfortable angle. This will also help Doepker Industries save costs by allowing them to produce as many of these units as desired at a lower cost than if bought from a vendor. The client has also requested that the rotator be user-friendly, and is operated using physical buttons.

## **Background**

Rotators are used to reposition work pieces to access different angles. They rotate at very slow speeds, allowing precise placement and reducing angular momentum on heavy work pieces. To achieve rotation on these heavy items, it is often necessary to incorporate gear-boxes to slow down the speed of rotation and reduce fatigue on the prime mover.

Doepker Industries’ current rotators are either hydraulically powered or hand cranked, which then are reduced in speed through a gear-box. They are hoping to update their rotators with an electric drive system to increase accuracy and allow for recallable positioning.

A number of possible electric drives exist that can work in this application:

**Servo Drives** are capable of precise motion and provide a closed loop feedback, meaning the position of the rotor is always known. They can run at high RPM but lose torque as the speed increases. Speed is controlled through a drive controller and a position encoder.

**Brushless DC Motors** provide closed loop feedback, so the rotor position is known. They have an almost constant torque at both low and high RPM. Speed is controlled through a drive controller and a position encoder.

**Three Phase Induction Motors** are a simple and generally less expensive motor. They have a narrow limit of operating speed. Speed control is achieved using a variable frequency drive. They do not have closed loop feedback so the placement of the rotator would require external sensors.

**Stepper Motors** rotate through programmable microsteps and are capable of high torque for size. They do not have closed loop feedback so another method to track placement would be needed. Speed is controlled through a drive controller.

A programmable board, such as a microcontroller will have to be selected based on the drive selection and I/O requirements. This will integrate the motor control, rotator position, position recall and safety features.

## Scope

A rotator is to be designed that will mount to existing stands fabricated by Doepker Industries. It is to have user friendly control and position feedback for recalling locations. Parts selection, circuit design, programming, integration and commissioning are to be completed by the student design team. Doepker Industries will provide support in the areas of mechanical integration.

This will be completed in the timeframe from September 2019 to March 2020, with the product design being completed by December 6, 2019, and commissioning to be completed in February 2020. All system testing will be performed at Doepker Industries, where all of the requirements may be tested in the environment of which the system is designed for.

Doepker Industries is to be supplied with enough technical documentation to fabricate the unit multiple times after the capstone project is completed. This will include a bill of materials(including technical specifications required for the material selection), wiring diagrams and program coding along with drawing for the physical mounting.

## Objectives

The main objectives of this project is to design and build a rotational welding assembly unit for Doepker Industries that can rotate an attached load to any desired angle which will assist operators with welding. The design shall not be any more difficult or less safe to operate than the current rotational assembly units currently used by Doepker Industries.

## Constraints

The following are the constraints of the project:

* The design shall rotate the load using primarily electrical means.
* Design schematics shall be submitted to Doepker Industries for production by December 6, 2019.
* The design shall be able to rotate to predefined angle positions on command.
* The cost to manufacture each unit shall not exceed $10,000.
* The unit shall have an emergency shut off button.
* The unit shall be operated using physical buttons.
* The unit shall be able to operate on a variety of power ratings used in the various facilities of Doepker Industries.

## Safety/Environment/Social Considerations

The only applicable concern would be safety throughout this project. The project will follow industry standards and the design will be both OHS and CEC compliant. In terms of environmental and social considerations this project is not applicable in that sense.

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# Initial Project Plan

## Discussion

The team consists of two electrical engineers and one computer engineer. Jordan’s study streams are Circuits and Power. Finally, Thomas’ streams are Digital Signal Processing (DSP) and Circuits. Jason’s streams are Digital Systems and Computer Software. Due to the focus areas of each team member, responsibilities will be split into the following roles:

**Jordan**: Hardware development (primary), controller development (secondary)

**Jason**: Software & controller development (primary), project management (secondary)

**Thomas**: Systems design (primary), project management (secondary)

## Risks to Project Performance/Schedule

A list of risks that may impact the quality of the final product or project schedule include:

* Equipment lead times - some components that will be used in the design may have long lead times because they aren’t mass-produced products.
  + This will be mitigated by ordering components immediately after a final design is chosen.
* Component reliability - there is a possibility that the components ordered will not be reliable due to being new products, or due to being specialty components which may not have been tested to the extent of a component meant for larger market.
  + This can be mitigated by ordering components from more experienced vendors in the market, as well as avoiding ordering products that were recently introduced to the market.
* Outsourcing production - Doepker Industries will be helping build parts of the rotational unit, primarily the head/tail frame. Poor communication of design may result in Doepker building parts which may not be suitable for the design that the team envisioned.
  + This will be mitigated by creating clear documentation that will communicate exactly what the team wants built by Doepker Industries, and by communicating with Doepker to prevent misunderstandings.
* Unit is operated in an unexpected environment - Doepker Industries has multiple factories where the unit will be operated. Each factory will have different operating conditions, with the most important factor to keep in mind when designing the unit being that the unit must be compatible with the electrical systems used at each factory.
  + The team will design the unit to be compatible with all of the sites that the client provides electrical specifications for.

## **Deliverables**

* Bill of Materials (BOM)
* Schematic diagrams
* Circuit board layout
* Software (firmware)
* Factory Acceptance Test Procedures
* Factory Acceptance Test Results
* System design document
* User manual
* System Block diagram
* Final Report

## Milestones

Listed below are major project milestones and their expected completion dates:

|  |  |
| --- | --- |
| **Milestone** | **Date** |
| Problem Definition/Project Plan | October 1, 2019 |
| System Requirements Specification | October 25, 2019 |
| System Design Document | December 5, 2019 |
| Begin Unit Production | December 6, 2019 |
| User Manual | December 26, 2019 |
| System Verification Plan | January 6, 2020 |
| Perform Factory Acceptance Testing | February 13, 2020 |
| Final Report | April 10, 2020 |

## Work Breakdown Structure

Attached below is a table detailing the person responsible for each task in designing the system and how many hours are budgeted for each task:

## Gantt Chart

A gantt chart is attached below to show the general timeline of the project: