Senior Design Project Description

Company Name	*CIRCOR*	Date Submitted	*4/21/2020*
Project Title	*Twin-Screw Pump Wear Testing* **(CIR_WEAR)**	Planned Starting Semester	Fall 2020

Personnel

Typical teams will have 4-6 students, with engineering disciplines assigned based on the anticipated Scope of the Project.

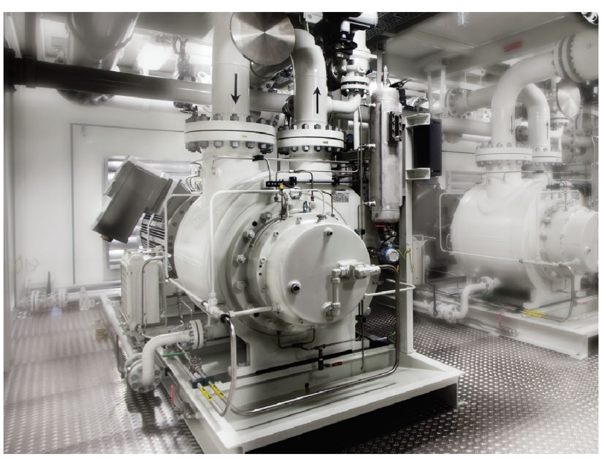
Please provide your estimate of staffing in the below table. The Senior Design Committee will adjust as appropriate based on scope and discipline skills:

Discipline	Number	Discipline	Number
Mechanical	5	Electrical	1
Computer	1	Systems	
Other ( )			

Company and Project Overview:

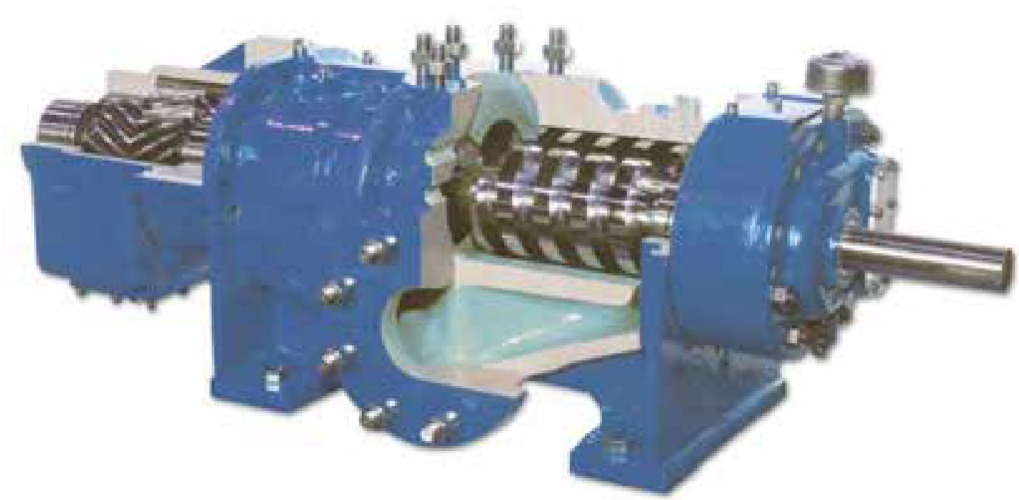
CIRCOR is a market-leading, global provider of integrated flow control solutions, specializing in the manufacture of highly engineered valves, instrumentation, pumps, pipeline products and services, and associated products, for critical and sever service applications in the oil and gas, power generation, industrial, process, maritime, aerospace, and defense industries.

The CIRCOR facility in Monroe NC manufactures Twin-Screw, 3-Screw and Gear pumps for a wide range of Industrial applications including chemical processing, mining, lubrication, hydraulics and oil production.



Project Requirements:

CIRCOR manufactures a wide range of Twin-Screw pumps under the Houttuin, Warren and Tushaco brand names. These are used in a range of difficult pumping applications – typically as the “pump of last resort” where other pump types would fail to operate reliably. An example of the pump is shown below.

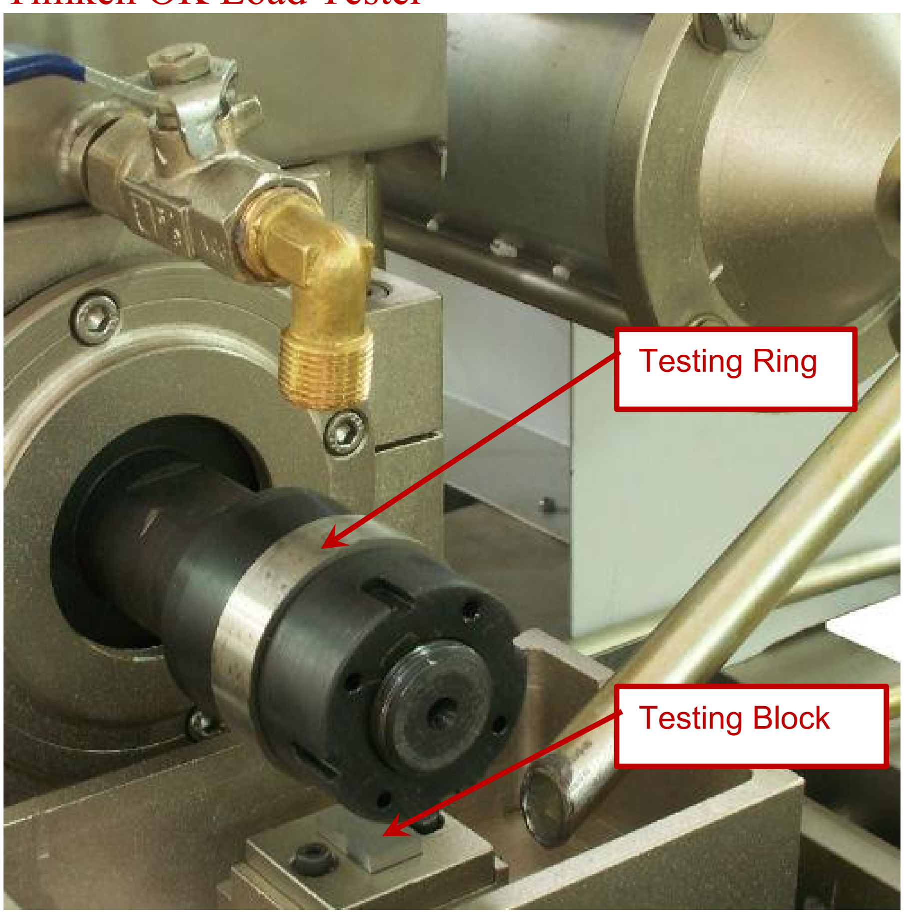


To extend the operating envelope and longevity of these pumps, various surface treatments and coatings are applied to working surfaces. Of particular note are the pumping screw outer diameters and body/liner inner diameters (bores) that form the primary operating clearance. In the challenging applications (where these pumps are most often used), these surfaces experience 2-body abrasive wear, 3-body abrasive wear, adhesive wear (aka galling) and corrosion simultaneously. Material loss from those processes can rapidly degrade pump performance by opening the running clearance and increasing 'slip' of fluid from the discharge back to suction.

Such extreme conditions require us to test new coating solutions before they can be offered for sale. Coating failure can result in pump damage or seizure and potentially clog or damage a customer's downstream equipment if debris is released.

For those reasons we currently perform two levels of testing before rolling out a new coating solution: 1) block-on-ring wear testing using a modified Timken Lubricant tester (see example below), followed by 2) functional testing of a full scale pump prototype. Very few new coating technologies have progressed to round 2 testing due to the prohibitively high cost of fabricating (and potentially destroying) one of these complex pumps. (typically >$50,000)

Timken OK Load Tester



Experience has shown that standardized wear tests like block-on-ring provide a reasonable indication of adhesive wear performance but do not adequately simulate the complex forces seen in real pump service. Coatings that held promise in small-scale testing would inexplicably fail or delaminate during pump testing. Without a more economical method to screen for these complex failures it is difficult to take advantage of many of the new surface treatment technologies available in the marketplace.

The goal of this project is to design an intermediate-cost wear test rig that closely simulates the forces on 2-screw pump's OD and bore surfaces and can be used prior to (or eventually in lieu of) full scale pump prototype testing. We envisage a spindle (simulating the screw) running inside a journal (simulating the bore) with fluid being forced at pressure through the interface. Some aspects to be considered for accurately simulating pump conditions are:

- Achieving relevant surface speeds (up to 3000 ft/min)
- Applying relevant fluid differential pressure drops across the tester (up to 250 psi)
- Generating and circulating oil, water, and/or abrasive suspensions
- Controlling fluid temperature
- Creating 2-body 'Jet' wear
- Controlling spindle-to-journal clearance & parallelism
- Controlling and measuring the extent of spindle-to-journal contact
- Coupon size & its effect on manufacturability, bond strength & residual stress of coatings
- Measuring slip flow rate

Emphasis should be placed on (in no specific order):

- Safely handling corrosive water solutions & flammable hydrocarbons
- Minimized coupon cost
- Minimized expertise for coupon manufacturing
- Minimized assembly time & effort
- Minimized maintenance and repair requirements
- Maximized temperature capability

Expected Deliverables/Results:

- A documentation of design optimizations explored and the effect of each on simulation effectiveness vs. other tradeoffs such as complexity/lead time/cost/size etc.
- Design and build of a test rig that pumps fluid through the contact surfaces and measures the loads applied, torque, flow rates and temperature of the fluids during the test. Rig to use clean fluid as step 1 test, and as a step 2, allow particles to be introduced into the fluid.
- Model testing of the preferred solution of the design team showing failure of a coating known to pass block on ring testing but fail pump testing.
- Engineering drawings and 3D models of the components proposed for the preferred solution of the design team.

Disposition of Deliverables at the End of the Project:

Test rig will be demonstrated at Expo, then handed over to Circor at the completion of Expo

List here any specific skills, requirements, specific courses, knowledge needed or suggested (If none please state none):

- Knowledge of 3D modelling (SolidEdge preferred)
- Understanding of casting, fabrication and machining processes
- Understanding of GD&T as it relates to component dimensioning, tolerancing and drawing