EML 4551C – Senior Design – Fall, 2012 - Deliverables

Production Specifications

Team # 5 – Sensor Test Rig

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Introduction

This project is sponsored by Danfoss Turbocor, based in Tallahassee, Fl. The goal for the project is to design an improved method for testing the sensor rings that are implemented in the oil-free compressors. Turbocor manufactures large scale compressors that employ an oil free bearing system for controlling rotation of the main shaft. This system includes magnetic bearings that must consistently be corrected by fractions of micrometers to sustain correct position for the shaft rotating at extremely high speeds, circa 30,000 rpm.

The project scope is comprised of an improved method for performing measurable and extremely precise displacement, which will be used to calibrate the sensor rings. Another main focus is to maintain this precision displacement in three directions, lateral in the X and Y, and axial movement in the Z direction. The sensor rings must be accurate to no less than 400 microns. With all this displacement, it is also important for the test fixture to effectively maintain zero-backlash during the testing process. Backlash introduces unknown error in measurements that can lead to catastrophic results at the high speeds the compressors operate at.

In order to deliver an improved method for testing these sensor rings, this project aims to design a production test rig that implements high precision, displacement in three directions, and zero-backlash.

Production Specifications

The objectives of this project are to build a testing rig that will test the X, Y, and Z displacements. The maximum displacement of only 400 micrometers are tested, thus it is imperative that the measurements are precise. Although there are no size constraints for the

testing rig, our system must be low cost. The time to test the sensors is currently about 150 seconds. This is to be reduced if possible.

Sensor Mount

The mounting system for the sensor ring must be able to hold the sensor securely during use. Any movement of the sensor ring during testing would result in flawed measurements taken on the testing rig. The mount system must also be able to be quickly engaged and disengaged so sensor ring can be quickly inserted and removed into the mounting system.

A spring-clamp system may be optimal for this purpose as they can be quickly opened and shut while at the same time keeping the clamped item stationary. This system is currently in use for testing sensor rings. By compressing a spring, the surface attached to the spring can be retracted, therefore releasing the item being held. Screw clamp systems are another possibility. In this type of apparatus, a spring is rotated which drives a plate or other surface toward a fixed surface. As the gap between surfaces is closed, the item is secured between the two surfaces. These systems are currently used in precision motion devices such as drill mills and lathes. Of course, the sensor ring could also simply be bolted to the mount.

Precision Motion Device

The motion device for our test sensor rig must be able to precisely move the position of the sensor ring in the X, Y, and Z directions. Furthermore, it must be able to do this with pin point accuracy. The motion device is required to move a total displacement of 400 microns in all three directions while at the same time accurately tracking its position. Also, the motion device must be able to stop in three positions: -200 microns, 0 microns, and +200 microns for each

direction. However, X and Y directions have been identified as the largest concerns by Turbocor.

Several concepts are currently available for precision motion devices. Screw wedge systems, cams, and worm gears are all known to work for this purpose while at the same time creating minimal back lash.

The measurement system integrated to our precision motion device must be even more accurate. This will require a device such as a micrometer or Eddy current sensor to track our movement.

Cost

As of now, because it is still early in the design process, there has not been an exact budget determined. However the overall breakdown in expenditures can be estimated and thus a brief description on budget can be established.

In regards to product testing and fabrication, majority, if not all, of the materials and workspace will be provided by Turbocor. This includes but is not limited to, product construction materials, labor costs, and any testing costs associated with prototyping leading up to the final design. At this stage, it is unclear as to exactly what materials and how much will be required to complete the project. Testing costs are expected to be minimal due to the products purpose. Testing displacements around a mock compressor shaft are already performed at Turbocor, so testing the fixture should be simple and will be conducted at Turbocor.

		Engineering Specifications			
		X-Y-Z Displacements	Precision Measuring Devices	Sensor-Ring Mount	Fast-pace
Customer Needs	Automated	x	x		
	Efficient	x		x	x
	Independent movements	x			
	Low Costs		x	x	x
	Precision	x	x		x
	Reliability	x	x	x	
	Repeatable	x	x	x	

The house of quality chart above concludes that X, Y, Z displacements and its precision are the two most important aspects to focus on.