Validation and Design Optimization of a Reclaimer Screw System Using Micro-Measurements' Strain Gages

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Strain gages from Micro-Measurements, a brand of Vishay Precision Group (VPG), are used in applications where design verification and optimization are required. Using a combination of shear and linear patterns has proved effective for accurately determining torque and bending strains. Several variations of these two pattern types are readily available from Micro-Measurements.

To validate a new reclaimer screw design used in grain silos, TerraSource contracted with Bcomtesting to install and monitor strain gages used for determining torque and bending strains . The data collected will be used not only to validate, but also to optimize the current system, with the potential for reduced manufacturing costs.

Company/Institute: Bcomtesting Inc., Wake Forest, NC

Industry/Application Area: Agricultural, industrial material handling

Product Used:

- Strain gages, model CEA-06-187UV-350 (shear pattern for torque)
- Strain gages, model CEA-06-250UN-350 (linear pattern in bending)
- M-Bond AE-10 epoxy
- MR2-350-128, 350 Ω half-bridge completion module
- 3140RTV protective coating

The Challenge

Silo storage has been practiced for centuries. It is, therefore, a mature industry. However, loading certain materials for storage is challenging, because these materials do not load evenly into the silo; thus, creating undesirable forces on the silo walls. These loads can compromise the structural integrity of the silo. When combined with common wind loads, these forces have contributed to catastrophic failures.

Using a reclaimer screw system at the bottom of a conical-shaped silo dramatically reduces the potential for side or offset loading caused by uneven distribution of material. The screw (see Picture 1) forces the material towards the bottom, and by slewing around the bottom drives the material on top to follow the cone shape, resulting in an evenly distributed load (a reclaimer installation at the bottom of the silo can be seen in Picture 2). Material sticking to the side is forced down, flowing to the silo's center for retrieval. Material accumulations on the side are then reduced and potential damage to the structure is avoided.

Optimizing and validating the reclaimer system is quite difficult since load data is not easily acquired Using strain gages on the screw shaft before the equipment is placed in service represents an easy and simple way to validate or optimized a design.

The Solution

When TerraSource contacted Bcomtesting, their new reclaimer screw system was in its intial design phase. Installing strain gages on the final product would have been quite challenging since the area to be measured isn't readily accessible after installation. In cooperation with TerraSource, Bcomtesting slightly modified the area where the strain gages are installed to include an access panel, thus providing the necessary reclaimer system protection without negatively impacting its normal operation. (see Picture 4).

Bcomtesting installed two full-shear-bridge patterns to measure torque and two half-bridge patterns to measure bending. The two duplicate strain gage bridges were offset from one another by 90° These redundant circuits were necessary to validate data while providing a safety net in the case of damage during the initial start-up period. A coating of 3140 RTV protectedthe installation from damage by material entering the gage area during loading. Precautions were necessary, because field failures would have been extemely difficult to repair.

After installing the gages in ourfacility (Picture 5), Bcomtesting sent the reclaimer screw back to TerraSource in South Carolina in order to receive the drive assembly and to be shipped to the final installation location in Kentucky. After the reclaiming system was installed, a short waiting period was necessary in order to collect enough material in the silo during harvest, allowing a complete analysis of the system.

With a partially filled silo (Picture 3), Bcomtesting installed a wireless data collection system on-site to acquire strain data. It was only a matter of collecting a few wires since everything else was pre-installed in the company's facility several months earlier. Over a period of two days, Bcomtesting collected data representing extreme scenarios. One of the most diffcult was using the screw in a "wiper movement" without rotation, which caused the screw to bend with no ability to force material down. Bending strain was found to be the critical component for the new design. Since the reclaimer screw is installed in a cantilever configuration, this was not unexpected.

Other scenarios were tested with different combinations of speed and rotation, both in bending and in torque. Figure 1 shows an example of the data collected during the process. With some basic calculations, it was possible to determine torque and bending at the gage locations. It was concluded that the screw system worked as intended, was overdesigned, and could be optimized. For the material studied, screw diameter size can and the drive motor can be down-sized, which reduces the weight of the system as well as the size of the installation brackets.

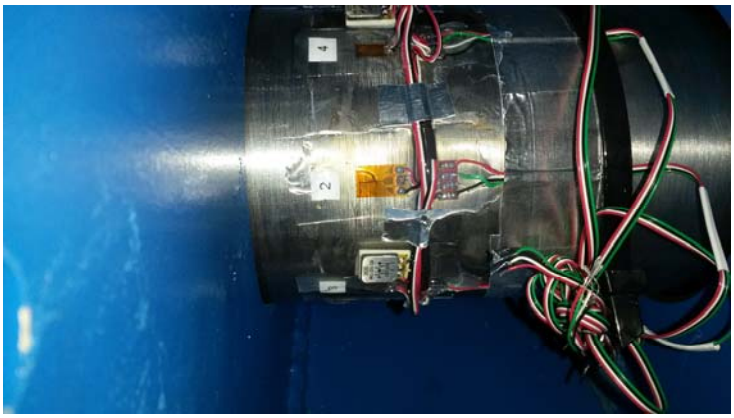
Picture 1: Reclaimer screw

Picture 2: Reclaimer screw system installed at the bottom of the silo

Picture 3: Silo view from outside

Picture 4:
A: Strain gage area modified to be protected.

B: Strain gage area with its protective cover



Picture 5: Strain gages installed on the reclaimer screw shaft: two full-bridges in shear patterns (torque) and two half-bridges in linear patterns (bending)

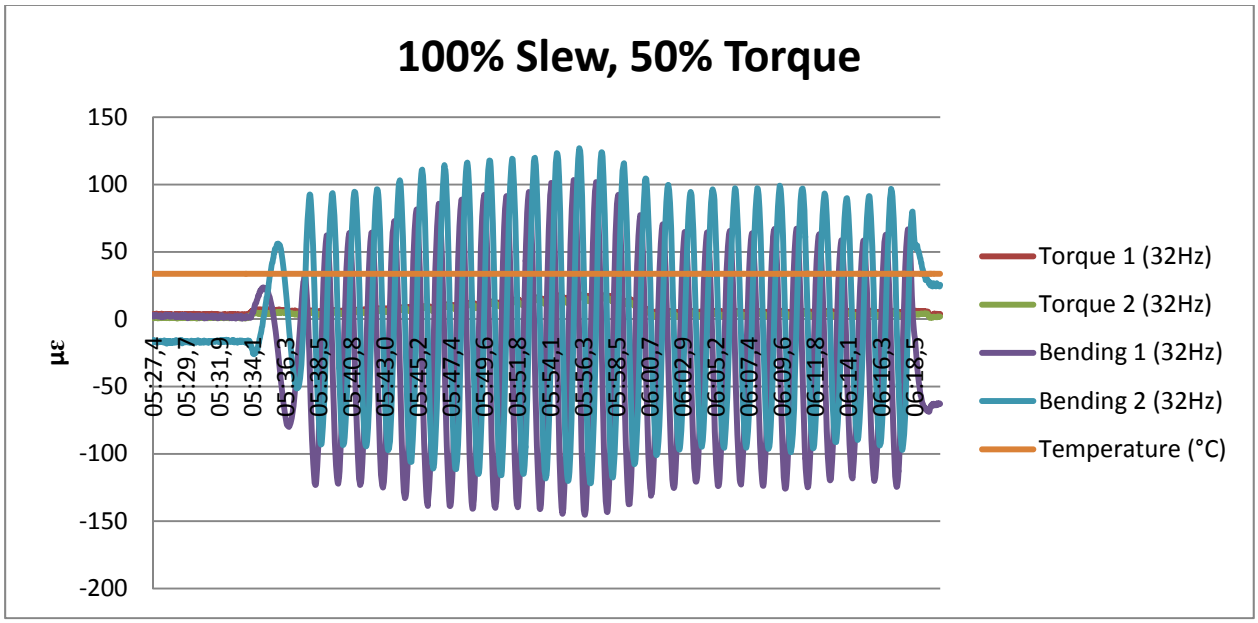


Figure 1: Example of the type of data collected during the reclaimer testing

The User Explains

Bcomtesting chose Micro-Measurements strain gages for this application because of the gage quality and consistency. Because of the many different applications with which Bcomtesting becomes involved, quality products are extremely important to ensure accurate data first time, every time In the case of this reclaimer system, since data collection was performed in the field and post-installation changes are almost impossible to make, a proper installation and the quality of the materials used were crtitical.

Mike Barron, director of engineering at TerraSouce Global explains, “We designed the reclaimer to be able to withstand stronger forces and higher stresses. By using strain gages, we could not only validate our design, but there was the possibility of optimizing it to potentially reduce our manufacturing costs and provide a more cost-effective solution for our future customers. Bcomtesting’s expertise was instrumental in getting us the information in a timely manner. Since we are not experts in strain gages but rather in material handling equipment, it was a no-brainer to use their services.”

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Acknowledgement:

Bcomtesting offers a wide variety of testing and strain gage capabilities. The company offers state-of-the-art physical and mechanical testing services at a fraction of the cost of most labs. Bcomtesting's cost per specimen is significantly less than that of competing testing companies for mechanical properties and for physical properties determination. Bcomtesting also offers strain gage installation and data acquisition services to its customers. These services can be performed at their location, in our facility, and on most materials (composites, metals, non-metals).

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