RECLAMATION Managing Water in the West

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The Knowledge Stream

Research Update

Catching Problems Early: Predicting Shear Pin Failures With Acoustic Emission Sensing and Analysis

Monitoring turbine linkage shear pins and detecting shear pin failures at Reclamation's powerplants

Bottom Line

Under certain conditions, the failure of a turbine wicket gate shear pin can cause substantial damage to the turbine of a hydroelectric generator. This research explores using acoustic emission and other types of sensors attached to shear pins to detect the start and propagation of a crack before the shear pin breaks so that the unit can be shut down to prevent further damage.

Better, Faster, Cheaper

It is crucial that Reclamation keeps its powerplants running. By detecting shear pin failures in time, operation and maintenance costs can be reduced, powerplant availability can be increased, and Reclamation's infrastructure can be preserved. This also provides current and relevant information on the real-time condition of powerplant equipment, reducing the downtime needed for maintenance. This preventative maintenance can generate significantly more hydropower and avoid more costly failures of a turbine component.

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Problem

In the past, when hydroelectric units were manually controlled, it was common to staff plants with a plant operator(s) 24 hours a day, 7 days a week. A major element of the plant operator's job was to monitor the unit—to listen for abnormal sounds and to take action to shut the unit down if a shear pin failed. Today, it is more common to remotely control plants or units. Most Reclamation plants are not staffed on weekends and some smaller, remote located plants only see occasional maintenance staff visits during the workweek. This puts the power generation units at a high risk, as no one is around when a serious problem develops.

Finding problems early then becomes key to avoiding serious failures. Most hydroelectric turbines have around 20 wicket gates, each with a shear pin, that control the waterflow into the turbine. Shear pins are designed to shear or break if there is a mechanical overload on the wicket gate and are sacrificial parts that prevent more expensive parts from being damaged.

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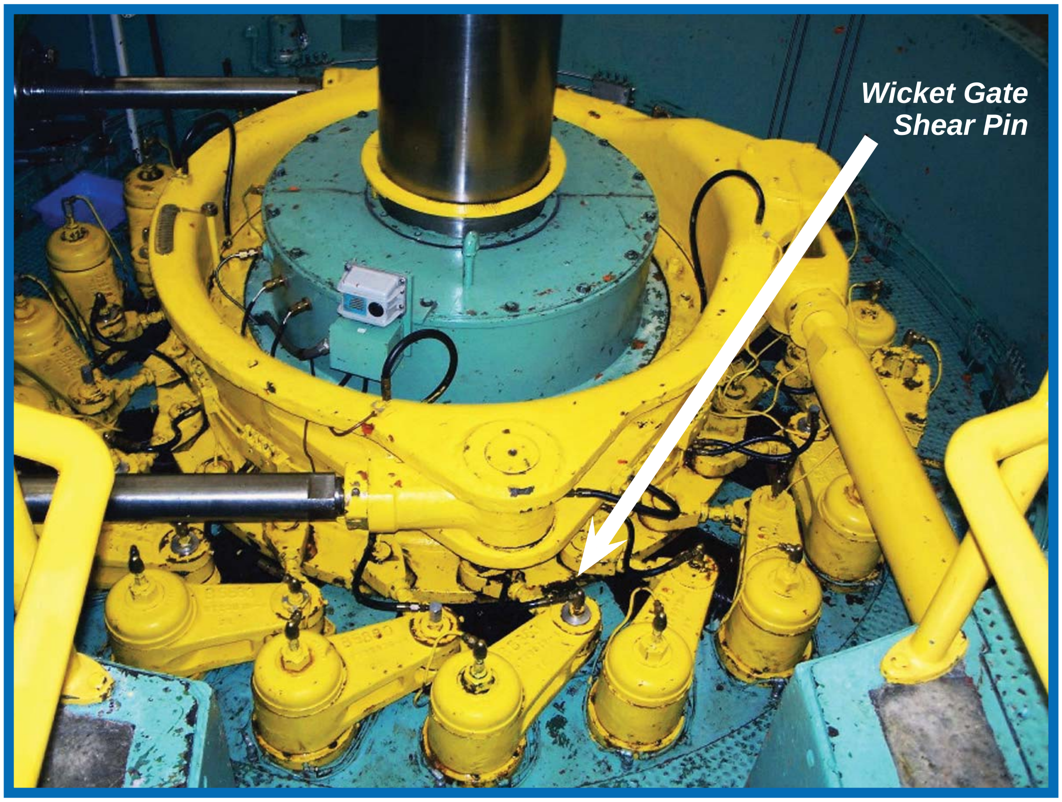

Hydroelectric turbine at Flatiron Powerplant. Photograph courtesy of John Germann.

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Yet, without a way to detect when a shear pin fails, the turbine will continue to run and risk even more damage. A wicket gate with a broken shear pin disrupts the waterflow and can cause the unit to severely vibrate. On occasion, the gate will violently slam closed causing adjacent wicket gate shear pins to break, creating a cascading effect of failures. Hydraulic imbalance created by the uncontrolled gates can move the rotating runner into destructive contact with the guide bearings and stationary wear rings. A number of hydroelectric units within the industry have suffered severe damage from not detecting a shear pin break early enough to shut the unit down in time.

Solution and Application

Using acoustic emission sensors is a promising method for detecting shear pin failure early. Acoustic emission techniques have a proven history for detecting cracks. When external forces or internal pressures cause discontinuities within a material, it emits stress waves at the onset and during crack growth. In a shear pin, the pin is stressed by an applied load. Acoustic emission sensors can detect this early release of energy and provide warning signs prior to the sudden failure of a material, in this case, the shear pin.

There is increased evidence that fatigue may also contribute to frequent shear pin failure with older shear pins. This Reclamation Science and Technology Program research project examined ways to effectively detect fatigue crack propagation prior to failure. Reclamation looked at detecting shear pin failure by continuously monitoring acoustic emissions through the crack process—from the early start of microcracks in the stressed pin through ultimate failure. The ultimate goal of the research is to design a detector that is non-intrusive to the pin, easily adaptable to any kind of shear pin, robust, reusable, cost effective, and maintenance free.

Understanding the fundamentals of shear pin cracking and fatigue-related issues of metal shear pin failures will lead to better methods to protect hydroelectric turbines from catastrophic failure and reduce maintenance requirements. Laboratory results so far have led to a better understanding of how shear pins fail and of the material science used for shear pins. These results have shown that acoustic emissions may be a useful method to detect shear pin failure.

Future Plans

Reclamation plans on further laboratory work and then testing results in the field. If a successful shear pin protective device can be designed and constructed, it will be available and deployed to Reclamation powerplants as another tool in the overall machine condition monitoring package. Findings will be shared through technical papers with Reclamation and the hydropower community.

More information

www.usbr.gov/research/projects/detail.cfm?id=7567

"The ability to predict some shear pin failures would be advantageous. Replacing shear pins would no longer be a "hurry-up-and-react" situation resulting in forced outages. Instead, shear pins could be replaced during planned outages. While this process may not predict all failures, even finding one or two could save millions of dollars in damaged equipment."

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Collaborators

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