Safety improvements for container crane brakes

This is the second article in a series being written for WorldTemp, assy by Bill Casper, PE of Casper, Phillips & Associates, Tacoma, Washington.

As explained in the first article, it is necessary to have adequate thermal capacity as well as adequate braking friction. Industry practice is a little shaky when it comes to ensuring adequate thermal capacity because full scale drop tests facilities are not available.

Therefore to perform a proof test for a new crane it is necessary to use that crane in lieu of a drop test tower. To minimize the risk of a proof test failure and to provide maximum operating safety, it is best that all brakes act as fast as physically possible.

This is fine so far as it goes. Let us assume we have done everything we can to ensure the brakes can always stop the main hoist system. But when can having too much braking capacity be dangerous?

One is too many

Here are a few examples. They occur infrequently; perhaps never occurred. They are classic examples of low probability of occurrence and high consequence of failure.

A dramatic accident occurred when a crane suddenly became unsteady and rolled over before the crane operator could release the twill locks. E-stopping the main hoist brakes would have caused the hoist ropes to pull down on the boom and possibly overturn the crane.

The crane operator saved both himself and the crane by calmly letting down rope while tripping backwards to gain stability. He pushed E-stop but the hoist ran out of rope after the operator had trolleyed back some distance. By this time the barge had completed the roll over and there was only minimal overspeed as the rope broke free of the drum.

Another actual case is a combination of a container jammed in the spreader twistlocks and the spreader rossing over the container. A horizontal pull develops as the container is accelerated and the drum continues. The hoist ropes have little or no redundancy in the case and the hoist brakes could not be manually released.

Mooring failure

What if a ship has a mooring failure and pulls away from the dock while the crane is picking a load from within the ship? A few years ago a home video clip of a crane collapse was transmitted worldwide via e-mail. This accident was reported to have been caused by a mooring failure that let the ship move down wind along the dock while the crane was operating.

A similar accident could occur if the spreader is deep in a cell when the crane gets hit by a microburst wind. The crane starts to run away, the hoist operator hits E-stop and hoist rope tension rapidly increases pulling mostly downward yet doing very little to restrict the horizontal wind force.

Evidence pointer

Also consider the following case. The evidence indicated that it happened, although it was not confirmed. The crane is jammed on a hatch cover and the crane operator is unable to break it loose. The crane has suffered injury in the event.

The crane operator saved both himself and the crane by calmly shutting down the crane and manually releasing the brakes.

“Gantry snag”

We have coined the term “gantry snag” to describe the latter three failure scenarios. Gantry snag is depicted in Figure 1. Picture that the container is attached to the ship and the gantry moves to the right. Or the gantry stays fixed and the ship moves to the left. Either way the hoist ropes start vertical with all hoist rope tension pulling straight down. For gantry snag there is no initial horizontal pull on the gantry.

As the horizontal pull develops it is accompanied by a large increase in vertical pull. This continues until either relative motion stops or the magnified rope loads cause something to fail - boom, fore-stay, trolley, or hoist rope.

Uusually the hoist ropes have a safety factor of between 3.0 and 5.0. So the crane will survive if nothing else fails and relative gantry motion stops. But there is no redundancy to stop the buyer's purchase specification requirement. Perhaps the suggestion given above will be included as part of this continuing process. Certainly, nothing has been suggested that is technically challenging, but implementation always depends on economic justification.

A practical answer

With some R&D effort a similar automatic brake release system could become an industry standard. Here is one practical solution:

• Container crane brakes are set by mechanical springs and released by hydraulic pressure. For emergencies that include loss of electrical power a back-up hydraulic release could be used one that has an accumulator to store pressurized hydraulic fluid and stand-by battery power to the necessary controls and valves.

• Copy automotive anti-lock technology to invent a release that produces a pulsed series of release cycles. Pulsed release has been demonstrated to be necessary for consistent and reliable anti-lock braking.

• Use the concurrent condition of zero hoist tachometer and overload trip to automatically signal a pulsed brake release mode. Stop this mode when the overload signal reduces below operating level rope tension. Restart mode if the overload signal again reaches the trip level. Continue until crane driver or maintenance engineers manually take control of the crane.

Not transparent

Most accidents involving container cranes go unpublicized and uninvestigated. There is no equivalent to the accident investigations that follow airline or railroad accidents.

It is human nature to be reactive rather than proactive so the usual results are knee jerk actions by those directly involved. This approach to accident safety has served over a few decades to produce safer and safer brakes gradually. Almost all such improvements have been made in response to the buyer's purchase specification requirement. Perhaps the suggestions given above will be included as part of this continuing process. Certainly, nothing has been suggested that is technically challenging, but implementation always depends on economic justification.

Graphical descriptions

Plots of typical loads on one of the hoist ropes due to gantry snag are shown in Figures 2, 3, 4, and 5. These plots are all for the same assumed gantry configuration. There is no particular significance to that configuration. They just happen to be the worst case for gantry snag because total rope length is shortest.

The common factors with all the accident scenarios described above are:

• Hoist is stopped as the hoist trolley is varying speed.

• Hoist tension reaches overload tension so the overload switch trips.

• The operating brakes are set and the emergency brakes are set.

• If there is little or no danger if the hoist brakes could be automatically released in a controlled manner.

Figure 1: “Gantry snag.” The spreader twistlocks are engaged, the container is attached to the ship ... (Casper, Phillips & Associates).