

# Minjng Magazine

## The one and only

Carly Leonida travelled to Arizona in July to see the very first Joy Global 2650CX hybrid excavator in action

Carly Leonida | 25 Aug 2016 | 10:07 | Feature



*The concept of a 'hybrid excavator' first came to light in 2010*

As the title of this article suggests, there is currently only one 2650CX in the world. However, I doubt it will remain this way for long.

Announced in 2012 at the MINExpo tradeshow in Las Vegas when it was still in the concept stages, the 2650CX has come a long way.

From its humble beginnings as a set of drawings at Joy Global's headquarters in Milwaukee, Wisconsin, through to voice-of-customer surveys and eventually construction, the prototype is now happily ensconced at ASARCO's Mission complex, an open-pit copper mine located near Tucson in Arizona.

The 2650CX is a 'hybrid' in every sense. Featuring Joy Global's SR (switched reluctance) drive technology, it offers the ability to leverage both diesel and electric power, providing a 10-15% reduction in the total cost of ownership compared with a hydraulic excavator – its main competitor. But, and this is where it gets really interesting, the 2650CX, which closely resembles a rope shovel, also features hydraulic components, which give it more mobility and nimbleness than a rope shovel, and as much breakout force as a hydraulic excavator. It is quite literally in a class of its own; a new type of excavator.

## **Back to the drawing board**

The concept of a 'hybrid excavator' first came to light in 2010 when Joy Global initiated a series of voice-of-customer surveys. The aim was to break into the excavator market.

"We've been developing and evolving our P&H rope shovels for a long time and we thought, there are so many excavators sold per year, we need to get into this space somehow," says Kristina Fierro, Joy Global's product manager for hybrid excavators. "Our customers were saying 'give us something with the selectivity and mobility of an excavator, but with cheaper operating costs'."

She continues: "We know our rope shovels have a really low cost per tonne because they're electrically driven, so we decided to leverage the SR technology that was acquired along with the LeTourneau brand. That is what made this project possible. This machine is a true hybrid combining electric and hydraulic elements. It gives customers the best of both worlds."

The machine essentially required a clean-sheet design. Joy's team of engineers were assigned a set of criteria and investigated various solutions, but the hybrid model proved the only way to achieve the functional specifications required.

Looking at the machine from the ground up, the lower works – the car body, crawler frames and shoes – are similar to Joy's rope shovels but fundamentally different. The 2650CX sits in the same size class as the 59t-capacity P&H 2800 (essentially the middle of the company's rope-shovel range). However, the only common component is the lower rollers. "This machine has more in common with our wheel loaders," explains Fierro.

Joy Global has utilized castings to deal with parts such as the boom foot, head of the handle, front idler and tumbler, which are high-stress areas on its rope shovels.

At first glance, the boom structure and digging components look similar to a rope shovel, but look closer and there are some subtle but very important changes.

“The handle or crowd makes the bucket go in and out, the boom allows you to hoist, or go up and down, and then we added hydraulic cylinders that allow the bucket to articulate,” explains Fierro. “So rope shovels can only crowd and hoist together. With this machine, you have the same functions but now you can turn the joy stick to make the bucket curl. It’s much more selective and creates a very powerful attachment.”

In fact, the 2650CX has the same hoist force as the mid-range 2800 rope shovel, but the same crowd force as the 4100, the largest model in Joy Global’s product range.

“On an excavator, the hoist and crowd functions are controlled with hydraulics, which gives them a lot of power at the front end,” says Fierro. “However, with all those functions competing for the same hydraulic fluid, you eventually start to lose some pressure and subsequently power.

“The 2650CX has a hoist advantage because it has a fixed boom architecture without all the cylinders and sticks. It’s lifting less mass, which helps with fuel consumption, and using fewer hydraulic components allows it to maintain power while digging.”

When Joy Global asked its customers what they wanted, they asked for fewer hydraulic components as these usually require lots of maintenance and troubleshooting. Subsequently, the only functions on the 2650CX that run hydraulically are the propel function and the tilt functionality on the bucket. Everything else is electrically driven.

There are four cylinders on the boom: two control the tilt and allow the bucket to articulate, and two open and close the bucket. “We call this a bucket, not a dipper,” says Fierro. “With rope shovels you need to get the attachment into the tuck position to close the bucket using gravity, it’s just a latch mechanism that holds it in place. This machine has a clamshell bucket that can be opened and closed whenever; you’re in total control.”

The clamshell bucket features an ESCO Nemisys lip system that has been designed specifically to accommodate the 2650CX’s radial corners; a design similar to P&H rope shovels, which should theoretically use less force and fill the bucket more effectively than the equivalent square lip used on most excavators.

The boom is angled at 50° on the 2650CX, which allows it more reach than a hydraulic excavator, but slightly less than a rope shovel. “We designed the 2650CX to compete directly with hydraulic excavators,” Fierro explains. “The only time we plan to quote this against rope shovels would be in an emerging market, somewhere the pricing of shovels would be hard to compete with a manufacturer in say China or Russia.”

## **Packing a punch**

One of the most notable differences compared with a rope shovel is the addition of radiators that serve the 2650CX's two engines, and a grid resistor that allows excess regenerated energy to be dissipated as heat.

Inside the house, Joy Global has got smart with its layout and there is almost 360° access around the engines. Rather than coiling the hoist rope around an empty drum as with rope shovels, on the 2650CX the hoist transmission is housed neatly within the drum with a motor bolted to the ends.

The engines are each coupled to an SR generator that feeds electricity to a converter cabinet. Each engine/generator combo is also coupled mechanically to three hydraulic pumps, which pump fluid through directional control valves and out to where it is needed.

The 2650CX utilizes the same engines – MTU Tier 2 models – as the 1350 wheel loader but Cummins options are also available to suit customer preferences. Importantly, the radiators have also been sized to allow Tier 4 final units to be used too and Joy Global plans to offer both options.

When the machine regenerates power during hoisting down the bucket, and when decelerating from swinging over to a truck, the motors start to act like generators.

Power is funneled backwards and the generators then start acting like a motor as well. During these parts of the cycle, fuel can be cut off to the engines and the machine runs electrically, which has the dual benefit of saving the client money and also extending the life of the engines.

The regenerated power goes back into the system and if not used is burnt off on the grid, although, according to Fierro, this is a rarity rather than a regular occurrence.

“With the fuel consumption figures we’re achieving now, it’s clear most of the power that’s regenerated is getting used,” says Fierro. “We are testing our KESS technology to further those capabilities and it is something we will continue to evaluate.”

That technology will be featured on an underground loader Joy will be showcasing at the MINExpo 2016 tradeshow in September, as well as a full display highlighting its many uses of the Joy SR Hybrid Drive.

Joy has employed an open house on the 2650CX and removed the gantry and suspension cables completely to allow easy access to the hoist system and engines during replacement/rebuilds. “We’re targeting 20,000h for the engines,” explains Fierro. “That’s higher than most excavators; the 2650CX engines will use less fuel, which allows them to will last longer. The hoist motors will go between 25,000 and 35,000 hours, but this is a brand-new motor, so we’ll have to see how that goes, and the hydraulic pumps are expected to last about 15,000h.”

## **To market**

The Aussie market, which is a target for the next 2650CX sales, has strict safety standards and regulations. Joy Global currently makes additions/alterations to its loaders and shovels regionally to make them compliant. However, the 2650CX has been designed to be as compliant as possible from the factory.

Australia being the target market, what does the 2650CX offer in terms of automation? “We’re testing our adaptive controls which assist the operator, like we have on our rope shovels,” says Fierro. “There are also things that are specific to this machine; we will have a function for flat-floor cleanup. This allows the operator to use the machine to doze the floor in front of it, reducing the need for support equipment.

“We are also evaluating the efficiency of a return-to-tuck function and TrackShield, a product on our rope shovels, is also available on this machine. This mitigates collisions between the bucket and tracks.”

There is also a payload-measuring system on the pilot and the P&H PreVail system, which monitors all operating parameters, and walks through calibration and troubleshooting of various functions. “We will investigate full automation but that seems more of a requirement on trucks at the moment,” adds Fierro. “We’re focused on making things safer and more efficient rather than eliminating the need for operators on board.”

## **The perfect partner**

Having seen the 2650CX through the design phase, Joy Global began looking for a partner to pilot-test its new machine. It approached the ASARCO team with a view to setting up a partnership to field-trial the machine at Mission during the spring of 2014. Discussions were conducted through the summer and an agreement was signed in November 2014.

The companies have a long-standing relationship spanning nearly three decades, and Mission has a number of P&H rope shovels that have been on the property since the 1980s.

Joy Global currently has an Alliance supply/service agreement in place with ASARCO across all three of its properties, and knew that the conditions at Mission – hot desert climate, hard rock – would be a good test for the 2650CX given its target market.

Mission is also sufficiently close to Tucson to allow engineers from Joy Global HQ in Milwaukee to visit the site, and to its regional office in Mesa, Arizona.

“ASARCO was developing a long-range capital-equipment replacement roadmap for our loading equipment for life of mine in 2014,” Bjorn Meyer, mine manager for the Mission Complex, tells MM.

“Our 2300XPA fleet [of rope shovels] were high-hour machines, and we were in the process of locating a suitable replacement. The 2300s were not an efficient pass match for our recently refurbished haul fleet of Komatsu 930-4 haul trucks and the 2650CX seemed to have potential as a suitable candidate.”

Mission currently has two LeTourneau L-1850 generation 2 wheel loaders on site and in production. Meyer explains: “Hybrid technology has been attractive for us due to the fact that SR regenerative and capture hybrid technology on the L-1850 loaders enables Mission to move a ton of material for 30% less than our Cat 994F loader. This is primarily attributed to the reduced fuel consumption.”

## **From pilot to launch**

The pilot programme was split into two phases: phase one involved constructing the machine as well as commissioning and validation. The main assemblies for the 2650CX arrived onsite in May 2015, and Mission allocated an area away from production for Joy Global’s field-service team and engineers to build and begin testing the pilot.

“Joy Global still owns the machine; we wanted to do all the maintenance and learn from it,” says Fierro. “We didn’t know how long the parts would last; we still don’t with some, although they have been designed to a specific target. We needed someone to give us the opportunity to test it and Mission stepped up to the plate.

“Once the machine was able to go into the pit, we were effectively doing production for them for free, making it a true partnership. All the consumables and fuel that we used during testing we’ve credited back to them,” she adds.

Joy Global decided to use a modular design for the 2650CX to speed up assembly and disassembly time onsite. There are 12-15 main assemblies in total and everything was bolted together relatively quickly.

Fierro says: “It was a phenomenal build. We were targeting 14 days compared with our rope shovels, which usually take 60-90 days. The pilot was mechanically assembled in just eight days, although we extended the time to wire our electrical equipment and added 300 extra strain gauges to quantify our finite-element analyses on the steel, and we were commissioning the system for the first time.”

The biggest challenge was the time it took to calibrate a brand-new product and its control system. “We were pretty aggressive with our timeline,” says Fierro, “and that took a little bit longer than expected, but we kept the mine informed and they’ve been very accommodating.”

In February 2016, the machine moved down into the pit and the Joy Global team trained up eight of Mission’s operators.

Phase two of the pilot programme, which involved handing the 2650CX over to the Mission team to run, officially began in June. When MM visited, the 2650CX was digging its second 40ft (12m) bench and seemed in fine fettle. Meyer explains: “Our current 22-truck fleet is a mixture of eight 320t Komatsu 930E-1s and 14 930E-4s with WesTech beds. To load these with the 2650CX requires five passes to attain our payload target. We have begun discussions with Joy Global on increasing the payload capacity of the 2650CX with a larger-volume bucket to see if

we could make this a true four-pass match. “The existing bucket is 41 cubic yards (31m<sup>3</sup>) that can swing 65 short tons (59t) per pass, and we would like to see a 47-cubic-yard (40m<sup>3</sup>) option.”

Mission selected the 2650CX over a hydraulic excavator for a number of reasons. “Joy Global marketed the machine as being 25% more fuel-efficient than a comparable-sized hydraulic excavator, with less hydraulics and associated maintenance, which should yield a very competitive cost per ton mined,” Meyer says.

“What appealed to ASARCO was that the 2650CX married the best aspects of a rope shovel with that of enhanced mobility due to the lack of an electric tail cable, and this gives us flexibility when executing our mine plan that is heavily dependent on blending.”

He continues: “This also saves time and increases productivity when the machine setup is in a highly productive, high-priority mining cut.”

Mission is now running the machine 24/7 on a cost-per-tonne agreement, and phase two of the pilot programme is set to last 12 months concluding in June 2017.

“Based on Kristina’s figures so far, the 2650CX is doing better than planned in terms of fuel consumption,” Meyer notes. “The programme seems to be going well so far. We have a set of KPIs we agreed with Joy Global that need to be met by the end of the programme, so we’ll see how it goes.”

Fierro adds: “It’s been a testament to Joy Global that all our product teams and service support groups have come together to make the project work. It’s not often you get to be part of a project like this.”

## **What next?**

The 2650CX will have its internal launch in August and its commercial launch at the MINExpo tradeshow in September, and Joy hopes to have a sale within the 2016 fiscal year. Indeed, companies are already prospecting for unit number two.

“September is when it will be available to quote and details will be on our website,” says Fierro. “We’ve already had a couple of mines come to see the prototype in action, but we wanted to let this machine prove itself properly, we didn’t want to put it out too early.

“It’s a tough market right now. This is the best time to test a new product so that it’s proven and ready for when the market picks up,” she adds. “We expect this to be the basis of a whole new product line.”