System Eliminates Frac Sand Drying

By Ian Wilson,
Brian Dorfman,
Matt Oehler
and Kevin Fisher

DENVER–The typical horizontal well in Permian Basin tight oil resource plays now consumes more than 13 million pounds of frac sand on average. As per-well average proppant consumption has increased, a steady stream of technological and operational advancements has been introduced to optimize transport, storage and delivery capabilities to get more sand to each well site in less time in order to keep pace with the frac pumps.

The supply chain has been revolutionized by in-basin mines and last-mile logistical solutions such as mobile containers. These changes put the source of supply in close proximity to the well, remove bottlenecks to moving sand from the mine to the blender hopper, lower the delivered cost of frac sand, provide a storage buffer at the pad, reduce noise, and minimize dust and truck traffic.

The next step in further improving efficiencies and reducing costs eliminates a common but often overlooked step in the mining process: drying. Before transferring to the blender and pumping down hole, mined sand is washed, dried, sieved, stored and transported to the wellsite. Drying involves a combination of decanting (allowing water from the washing process to naturally drain and the sand to air dry in a pile), followed by handling operations to feed the sand into a kiln.

A new approach uses patent-pending equipment to screen, transport, deliver and meter wet sand from local in-basin mines to the frac blender, bypassing the drying process altogether. Wet sand in this application is defined as sand with a moisture content between 1% and 10% by weight. Frac sand historically has been dried prior to transporting to reduce its weight and improve ease of handling. A container carrying 25,000 pounds of sand that is 3% wet by weight translates to 24,250 pounds of net sand load and 750 pounds of water.

Drying operations introduce operational bottlenecks and adds incremental cost to each ton delivered. For frac sand mine operators, the capital and operating expenses for kilns can be considerable, and drying plants and storage are often limiting factors in mine output. An added benefit of eliminating drying is the positive environmental impact of eliminating billions of Btus of energy needed to fire kilns and the associated emission reductions. For oil and gas operators, drying provides no direct value to well construction, and once delivered to location, the sand is reintroduced to water in the frac fluid anyway.

Wet Sand System

The combination of the transition to in-basin mines near the point of consumption and next-generation sand metering, loading and screening techniques now makes wet sand delivery feasible. In addition to strong economic benefits, considerably less silica dust is generated when handling wet versus dry sand, reducing exposures from the mine to the well site.

Frac sand is washed after mining to remove clays and other off-size contaminants, and then separated using cyclones or hydrosizers to get the desired general grain size range. Cyclones and hydrosizers separate solids using a wet method. As noted, the wet sand then is decanted in a "wash pile" to allow the water to gravity drain and reduce the moisture content.

From the decanted wash pile, sand is moved to a hopper that feeds a conveyor belt to a drying kiln that removes the remaining moisture. As the dried sand exits the kiln, it is conveyed onto a series of screens to further separate it into tighter mesh size ranges before moving to storage silos for transport to the job site.

So why do mines go to the trouble and expense of drying? As any beach-goer knows, wet sand has an inherent cohesion. This granular cohesion is how a sandcastle can be built and maintain its shape. Water present between individual grains of sand acts like a weak glue holding them together. However, this stickiness restricts the ability to flow wet sand into or out of a train, truck, container, storage silo or hopper. At every settling point along the path from the wash pile to the frac blender tub, grain cohesion creates challenges to efficiently move wet sand.

Furthermore, metering using conventional sand screws ahead of the blender is compromised by the cohesion of the sand staged in the blender surge hopper. It is very difficult to create a steady stream of wet sand from the screw auger delivery process used in standard blending equipment. Cold weather can create another mobility challenge, with wet grains of sand binding together at freezing temperatures to create large chunks of aggregate.

Equipment Components

Overcoming cohesion between wet sand grains in order to enable efficient transfer is the primary challenge in developing technology to accommodate wet sand and eliminate the drying process

in the supply chain. Five key components have been engineered specifically to adapt equipment to handle both dry and wet sand:

- A wet sand screening/loading conveyor;
- A mobile container that can be quickly loaded and unloaded with wet sand;
- A transfer conveyor at the well site that can accept wet sand from containers and transfer it to a temporary hopper;
- A metering conveyor that receives input from the frac spread data van and outputs a defined sand volume to match job design; and
- A blender with open access to the blender tub.

Starting at the mine, the washed sand is screened through sieving screens that use sand velocity or screen angle along with a vibrating frame to eliminate undesired sieve fractions, particularly larger materials, to create a commercially acceptable wet sand at the right mesh sizes.

At the well site, the layout of hoppers, containers and conveyor belts used for dry sand require additional components such as controllable vibrators tuned for moving wet sand from containers to a transfer conveyor. A metering conveyor with a built-in scale measures pounds of sand per minute delivered to the blender tub, which is controlled by the blender's electronic request for instantaneous sand delivery rate.

Efficient and reliable container evacuation is essential in supplying sand to the blender hopper in high-intensity frac designs. Wet sand provides two key challenges during container fill operations. First, the angle of repose for wet sand is significantly steeper than for dry sand. Second, granular cohesion causes sand to stack rather than fill the full cross-sectional area of a container.

An open top-style container was developed to increase the available top opening from a 20-inch diameter circle on a standard dry sand container to a much larger opening for increased load volumes at reduced load times. A discharge chute with a snorkel-like head directs sand into the container more effectively, and uses the energy of sand falling into the container to better distribute wet sand to the sides and corners of the container. This results in load volumes as high as 28,500 pounds per container, similar to current dry sand loading processes (with this system, two boxes comprise a full

load of 46,000-57,000 pounds of sand per truck trip).

Once on the well site, dry sand can flow from a full-capacity container in less than 60 seconds. To meet the needs of frac designs with large fluid and proppant pump volumes, sand must be delivered to the hopper at a pace equivalent to 2.7 pounds per gallon for a 100-barrel per minute slurry rate (16,800 pounds of sand per minute).

A variety of equipment modifications were tested, but the most successful means of maintaining acceptable discharge times was applying vibration to transport containers and other components. Various vibration styles, frequencies, energy and placement positions were tested with varying degrees of efficiency. Ultimately, a vibration table was designed that could be mounted onto the primary conveyor system, independent to each container station. Power for the vibration system is available from the existing conveyor generator.

Metering And Conveyance

Once the wet sand exists the container, it drops into a hopper on a specially designed transfer conveyor belt, which enables reliable containment while moving large amounts of sand to the discharge point. The design prevents wet sand from overflowing the belt while eliminating packing off in the transition from container to conveyor belt.

In a traditional setup, dry sand would be dumped from the primary conveyor

into the blender's surge hopper, where sand screws would meter the sand at desired concentrations to the blender mixing tub. To replace metering screw augers, a "screwless" surge hopper was built to work in tandem with the wet sand conveying mechanism. It has steep, silicone-coated walls for reduced friction and a vibration system to continuously flow the wet sand onto the metering conveyor at the desired rate.

The creation of a known volume discharging from the surge hopper to the metering conveyor is essential. The uniform ribbon of sand created by the exit gate enables the weigh-in-motion system to deliver a precise volume stream of proppant into the blender tub. The variable set exit gate, combined with variable speed belt, allows the flexibility to meet real-time calls from the data van while delivering calibrated sand concentrations and volumes.

The metering conveyor also can be operated in manual mode so that an operator can adjust speed and delivered pounds per second to a variety of blender operating systems and conditions. The metering system also has cumulative volume counter functionality that can be matched to emptied container volumes to confirm mass balance of sand used during the frac operation.

Commercial Execution

The final wet sand system design was introduced in a field trial on a multiwell pad that consisted of a total of 120 frac stages designed with 500,000 pounds of

FIGURE 1

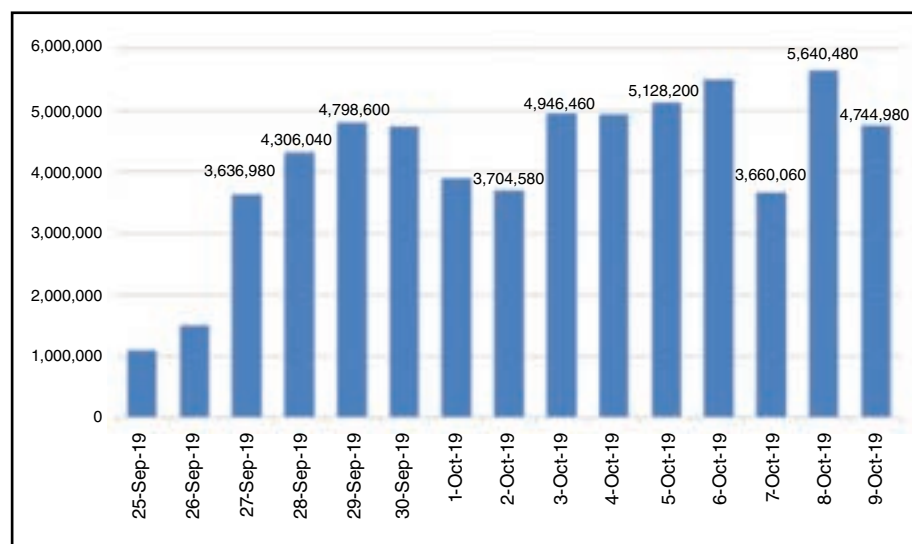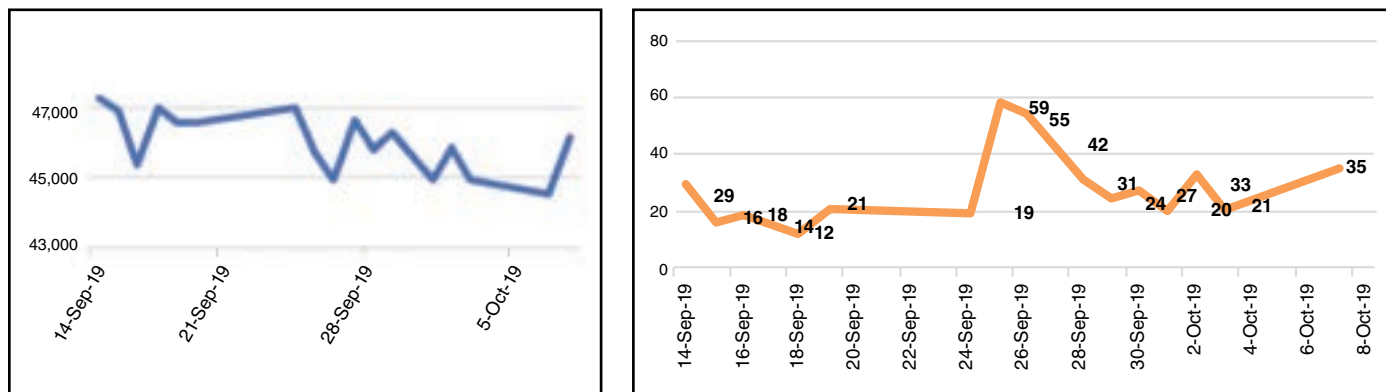**Total Wet Sand Load Weight Deliveries per Day**

FIGURE 2

Average Load Weight (Left) and Terminal Time (Right) for Wet Sand Pad

sand per stage, a 100-bpm slurry pump rate, and a maximum concentration of 2.0 ppg of sand. Expectations were to complete eight stages a day, and preparations were made to supply peak demand up to 12 stages/day. At the peak rate, up to 6 million pounds of wet sand would have to be loaded, transported, discharged and metered into the blender in a 24-hour period.

Wet product was screened at the mine through a 1/8-inch screen. Ultimately, more than 4 million pounds of wet sand, with a peak of 5.6 million pounds, consistently was delivered and metered to the blender over the course of 15 days (Figure 1). The wet sand system supplied average load volumes and mine load times similar to dry sand at ~46,000 pounds per load and 30 total minutes

spent at the loading facility (Figure 2).

In total, more than 60 million pounds of wet sand were delivered and pumped down hole while completing the 120 treatment stages. All identified aspects of cohesion from the wet sand were overcome and there were no interruptions to frac operation or the logistical supply chain. Sand inventory and equipment downtime during the pad was zero. Consistent flow of the 4-8% moisture content sand out of the container and onto the delivery system was not interrupted, allowing the metering belt to continually deliver accurate volumes to the blender tub at all concentration levels.

If the frac sand supply chain could be redesigned from scratch with the knowledge that sand could be delivered and metered to the blender without drying, the need

IAN WILSON *is manager of commodities and logistics at Ovintiv, formerly EnCana Corp. Before joining the company in 2014, he spent six years at Schlumberger in a variety of roles in drilling and completion segments. Wilson has a B.S. in civil engineering from Colorado State University and an M.E. in petroleum engineering from Texas A&M University.*

BRIAN DORFMAN *is a Business Development Manager at PropX. Before joining the company in 2016 he worked in Business Development at Halliburton. He has a B.S. in Finance & Accounting from Georgetown University.*

MATT OEHLER *is regional business development manager at PropX. Before joining the company in 2017, he had held a similar role for two years at Gulfstream Services. Prior to that, Oehler worked for Halliburton for 24 years in a variety of roles domestically and internationally. He has a B.S. in industrial engineering from Texas A&M University.*

KEVIN FISHER *is president and chief executive officer of PropX. Before joining the company in 2016, he served as president of Liberty Oilfield Services. Fisher began his career in 1979 with Halliburton, and subsequently served at ProTechnics and Pinnacle Technologies. He has a B.S. in natural science and physics from Cameron University.*

TABLE 1

Frac Sand Drying Cost in Permian Basin (Based on 2018 Consumption)	
Output (tons/hour)	5,000
Total hours/year	8,736
Yearly output (Tons of dried sand)	43.68 million tons
Utility cost	$2.50/Mcf
Btu needed to dry 1 ton of sand	350,000
Btu per gallon of gasoline	114,000
Gasoline equivalent to 1 ton dry sand	3.1 gallons
Price of gasoline	$2.50/gallon
Btus/hour	1.75 Bcf
Btus/year	15.29 Tcf
Total gallons equivalent consumed/hour	15,351
Total gallons equivalent consumed/year	134.1 million
Total cost (gasoline)	$335.3 million
Total cost (natural gas)	$38.2 million
U.S. average miles driven per car/year	13,500
U.S. average miles per gallon	25
Gallons per car/year	540
Cars taken off the road (CO_2 equivalent)	248,343

for decanting, kilns and upright storage would be eliminated. The wet sand loading and delivery system is a major step in that direction. In the Permian and other basins with available local sand resources, it eventually could enable the concept of a portable "pop-up" mine to source sand from acceptable-quality deposits within or near the acreage being drilled.

A significant amount of energy is required to dry sand from the washed pile, which generally is supplied by natural gas-fired kilns (an estimated 300,000-400,000 Btus per ton of dried sand). While natural gas is a very clean burning fuel, there are still emissions from the burners that require special air quality permitting. A well that requires 10,000 tons of sand using a natural gas fired kiln will emit between 173-230 tons of carbon dioxide to dry the product at the mine. If all the sand consumed in 2018 in the Permian Basin of West Texas (43 million tons) was powered by natural gas fired kilns, it would have emitted an estimated 744,133-992,177 tons of CO_2. As shown in Table 1, if that frac sand had bypassed the drying process, it would have removed the emissions equivalent of 160,000-250,000 cars from the road in 2018.

Such a scenario is now conceivable to reduce operational footprints, minimize silica dust exposures, reduce emissions and remove truck traffic from roads while achieving delivery volume goals and lowering overall supply costs.   ❐

THROUGHPUT!
YOU WANT TO TALK ABOUT THROUGHPUT?

YOU KIDDIN' ME?
PROPX EFFICIENCY KICKS ALL OTHER LAST MILE LOGISTICS TO THE CURB!

PropX Customers have routinely established new records in daily sand delivery.

Here are two recent milestones in daily sand per crew from different clients

WYOMING	**11,300,000LBS**
COLORADO	**13,400,000LBS**

FOR MORE INFORMATION, CONTACT US AT SALES@PROPX.COM OR AT (303) 317 8950