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Paper 29

THE FULLY ELECTRIC HDD JOB SITE

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ABSTRACT: The implementation of the electric direct-drive technology on all components of the HDD jobsite (drill, mixer/reclaimer and high-pressure pump), leads to the minimization of the environmental footprint and emissions (pollutants, noise, etc.). Speed of operations and responsiveness of the drill, combo mixer/reclaimer and high-pressure pump together, with the automatization of almost all operations of the drill, result in maximized productivity. The compactness of the systems minimizes transportation costs and logistic problems. Last but not the least, the high efficiency registered through more than 10,000 hours of continuous functioning, which confirms the high reliability of Vermeer electric technology.

1. INTRODUCTION

A typical large or complex horizontal directional drilling jobsite is made of several main machines, each one implementing a specific function or combination of functions. The horizontal directional drill is indeed one of the main components, typically together with one or more mixing units, one or more high-pressure mud pumps (sometimes onboard the drill, especially for small-scale HDD), one or more mud reclaimers, and eventually one or more storage tanks.
The most advanced countries in the world must achieve the ambitious goal of transforming their economies into carbon-neutral economies, by reducing the emissions of greenhouse gases and by transitioning the energy industry from fossil sources to renewable sources.
This involves the profound transformation of entire compartments of the industry, including automotive, transports and industrial machineries. In this paper the author will discuss how electrification of HDD machines represent the natural evolution of this industrial compartment.

2. THE ELECTRIFICATION OF HDD MACHINES

The electrification of machineries represents one of the strategies that can contribute to achieve a carbon-neutral economy worldwide. If there is still a debate about the effectiveness and feasibility of electrification of cars and road vehicles (generally speaking) to make the transport compartment more environmentally sustainable, there is no doubt that the electrification of non-road stationary industrial machineries represents an effective way to help reduce the environmental footprint and to increase the efficiency of this kind of machines, including HDD machines.
The traditional diesel-hydraulic architecture (Figure 1) of an HDD machine involves the use of an onboard or off-board diesel engine that typically powers a close-loop hydraulic system, where hydraulic pumps and motors power the mechanical output of the machine (the drive chuck in reference to a drill).
In the direct electric drive (fully electric) architecture, several electric motors power the different services implemented on the machine (e.g., rotation of the drive chuck, translation of the carriage, etc.).

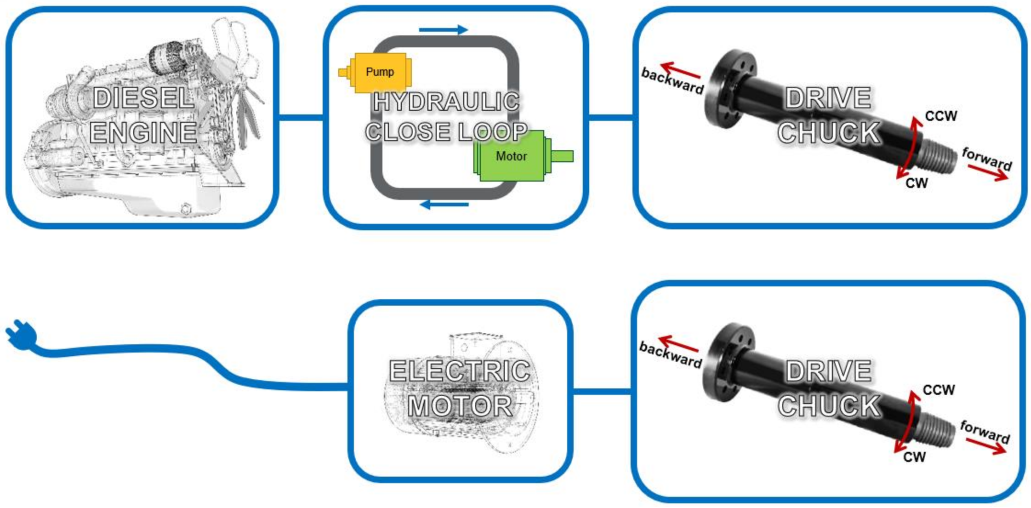

Figure 1. The traditional diesel-hydraulic architecture versus the direct electric-driven architecture

The electrification of HDD machines can be achieved in several different ways that are not the same from an architectural, functional and efficiency point of view.
The following are primaryways to electrify an electric HDD machine:

1. Electric-hydraulic (hybrid), powered by a diesel-engine generator
2. Electric-hydraulic (hybrid), powered by a battery or the grid
3. Direct electric-driven (fully electric), powered by a diesel-engine generator
4. Direct electric-driven (fully electric), powered by a battery or the grid

With the word “efficiency” we mean the amount of energy available at the mechanical output of the machine (e.g., the drive chuck in a drill) for each unit of energy entered in the system.
The energy conversions that take place in the different systems can be one, two or more, depending on the architecture of the system and the power source. This directly affects the efficiency of the system, as shown in Figure 2.

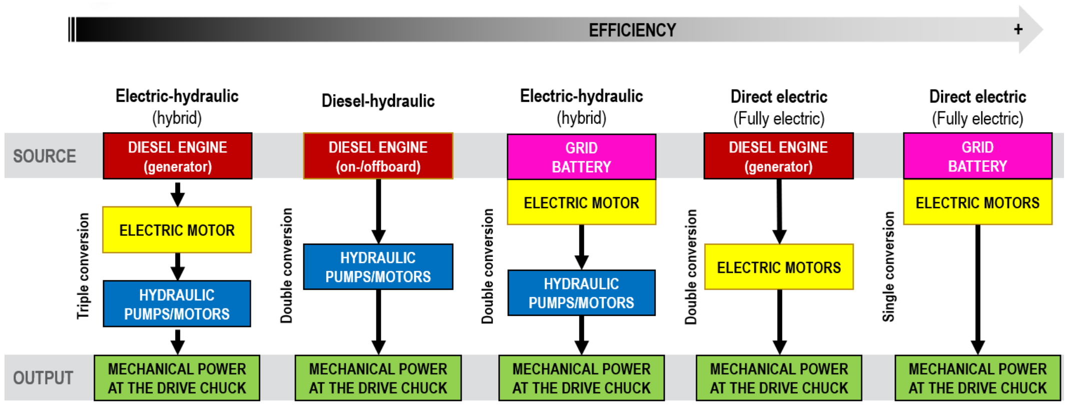

Figure 2. The different architectures of HDD machines

The higher the energy conversions, the lower the efficiency of the system, resulting in higher energy consumption. On average, while the efficiency of a traditional diesel-hydraulic HDD machine ranges around 70%-75%, the efficiency of a fully electric HDD machine is above 90%-95%.
A fully electric HDD is also a power-on-demand machine, this means that it consumes only the energy it needs when it needs. As a result, when comparing a traditional diesel-hydraulic with a fully electric HDD machine powered by a diesel generator, the higher efficiency of the fully electric system and the power-on-demand may result less fuel consumption during the same duty cycle.
Besides the high efficiency, other main advantages of the direct electric drive are the following:

- **Multiple options for a power source:** A fully electric HDD is independent from the way the energy is produced. It can be powered by multiple power sources such as generators (diesel, hydrogen and methanol, etc.), batteries or grid.
- **Minimal maintenance:** Electric components require less maintenance than hydraulic components. The lifespan of electric components is extended compared to hydraulic components.
- **High availability:** Of the machine to work based on less components.
- **Ease of service on the jobsite:** It is efficient to fix problems when working in muddy or wet jobsite conditions.
- **Torque:** It is direct.
- **Minimization of contaminant spills:** Less potential for contaminant spills due to a lower quantity of potential contaminant on board (hydraulic fluid which can be replaced with biodegradable oil).
- **Data logging:** With electric motors it is possible to measure and record any single data (e.g., torque and position) with high accuracy.
- **Low sound emission:** During operation, the equipment emits low sound decibels can be reduced significantly (below 80 db(A))

3. VERMEER FULLY ELECTRIC HDD JOBSITE

All the concepts briefly explained in the previous paragraphs have been implemented by Vermeer in a lineup of electric HDD machines. Hereafter the main characteristics of the machines.

3.1. VERMEER D120E FULLY ELECTRIC HORIZONTAL DIRECTIONAL DRILL

Specs	Value
Total weight (transport)	35 t
Transport length	15.4 m
Transport width	2.5 m
Transport height	3.1 m
Maximum thrust	1000 kN
Maximum pullback	1200 kN
Maximum torque	110 kNm at 0 rpm 60 kNm at 30 rpm
Fluid course	101.6 mm
Vise	• Full traveling vise assembly • Carriage vise 0.65 m travel • Break out torque 220 kNm • Open top 10-in, 16-in opening
Wireline	Rear load tensioning wireline drum
Catwalk	Full length
Operator’s cab	Off-board 10 ft
Drill pipe	Range 2, up to 7-5/8-in
Set-up	60 kVA on board gen set for maneuvering

All specifications must be considered as preliminary and subject to change.

Figure 3. Vermeer D120E, fully electric horizontal directional drill

3.2. VERMEER MR2000 FULLY ELECTRIC COMBINED MIXER/RECLAIMER

Specs	Value
Dimensions in transport mode L x H x W	ISO container size 24 ft long (7,6 x 2,7 x 2,5 m)
Weight in transport mode	17 t
Mixing and solids processing capacity	2.000 L/min at 20% SC (1,33 SG)
Mix tank volume (active tank)	18 m³
Reclaimer tanks volume	8 m³
Screen preselected choices	Coarse, medium and fine
Number of decks	2
Dual deck shaker, areas	Scalping: three panel polyurethane 0,81 m², Primary/desanding: nine panel wedge wire 2,43 m² Secondary/desilting: 3,6 m²
Desander hydrocyclones set	2x 10"- 20 deg
Desilter hydrocyclones set	12x 4” long-body
Processing pumps	
Desander pump	37 kW — Mission Magnachrome
Desilter pump	37 kW — Mission Magnachrome
Mix – Pre-pressure pump	37 kW — Mission Hi-Iron
Power supply	250 kVA minimum recommended (with pit pump)

All specifications must be considered as preliminary and subject to change.

Figure 4. Vermeer MR2000, fully electric combined mixer/reclaimer

3.3. VERMEER MR1000 FULLY ELECTRIC COMBINED MIXER/RECLAIMER

Specs	Value
Dimensions in transport mode L x H x W	ISO container size 20 ft long (6,5 x 2,7 x 2,5 m)
Weight in transport mode	11,7 t
Mixing and solids processing capacity	1,000 L/min at 20% SC (1.33 SG)
Total tank capacity	23 m³
Mix/active volume	18 m³
Screen preselected choices	Coarse, medium and fine
Number of decks	2
Dual deck shaker, areas	Scalping four panel polyurethane – 2,16 m² Primary deck (mesh-wire screen) – 2,2 m²
Desilter hydrocyclones set	12x 4” long-body
Processing pumps	
Desilter pump	37 kW — Mission Magnachrome
Mixing/pre-pressure pump	22 kW — Mission Magnum
Power supply	150 kVA minimum recommended (with pit pump)

All specifications must be considered as preliminary and subject to change.

Figure 5. Vermeer MR1000, fully electric combined mixer/reclaimer

3.4. VERMEER R500 FULLY ELECTRIC RECLAIMER

Specs	Value
Dimensions in transport mode L x H x W	Trailer version – 4,9 x 2,8 x 2,5 m
Weight in transport mode	Trailer version – 2,5 t
Mixing and solids processing capacity	500 L/min @ 20% SC (1,33 SG)
Process tank	2,3 m³
Screen preselected choices	Coarse, medium and fine
Number of decks	2
Scalping deck: polyurethane	Scalping two panel polyurethane – 1,08 m²
Primary deck (screen area)	Primary deck (mesh-wire screen) – 1,1 m²
Desilter hydrocyclones set	6x 4-in long body
Processing pumps	
Circulation pump	11 kW
Transfer pump	3.3 kW
Power supply	40 kVA

All specifications must be considered as preliminary and subject to change

Figure 6. Vermeer R500, fully electric reclaimer – trailer version

3.5. VERMEER SA2500 FULLY ELECTRIC HIGH PRESSURE PUMP

Specs	Value
Dimensions in transport mode L x H x W	2,74 x 2,23 x 1,74 m
Weight in transport mode	7,1 t
Drive type	electric, water cooled
Drive motor make	Danfoss
High pressure Pump	Tencniwell TW2500 HDD, triplex piston pump
Piston diameter	from 7-in to 8-in - standard 7-in
Maximum flow rate and pressure (7-in liners)	2400 L/min @ 80 bar
Relief Valve Setting	80 bar
Scalping deck: polyurethane	Scalping two panel polyurethane – 1,08 m²
Primary deck (screen area)	Primary deck (mesh-wire screen) – 1,1 m²
Desilter hydrocyclones set	6x 4-in long body
Power	
Voltage	380-440 Vac
Maximum output	340 kW
Maximum current draw	450 A
Recommended generator	150 - 425 kVA, 380-440 Vac, 450 A @ 50Hz
When connected to the grid	400 Vac @ 50 Hz

All specifications must be considered as preliminary and subject to change

Figure 7. Vermeer SA2500, fully electric high pressure pump

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THE FULLY ELECTRIC HDD JOB SITE
CASE HISTORY OF FULLY ELECTRIC RECLAIMER (Annex A)

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ABSTRACT: application of fully electric Vermeer equipment in Italian job site.

1. INTRODUCTION

In order to reduce the emissions of greenhouse gases many Italian customers have started to replace their old units with new Vermeer fully electric equipment.

2. CASE HISTORY

2.1. VERMEER MR2000 FULLY ELECTRIC COMBINED MIXER/RECLAIMER

First unit sold by Vermeer in Italy. This unit was used to manage drilling fluid in a job site near Macerata – Marche – Italy.

Main data of the project,

- Installation: Gas distribution
- Pipe material: Steel
- Bore length: ~ 500 m
- Final bore diameter: ~ 800 mm
- External fresh drilling fluid storage tank volume: ~ 40 mc
- External mud pit volume: ~ 60 mc
- MR2000 storage tank: 18 mc
- Drilling fluid: Bentonite/Additives
- API Screen designation: API 100 (D100 cut point min. 137.5 micron – max. 165 micron)

Operational data of the project,

- Number of steps reaming: 2 (20 inches – 32 inches)
- Theoretical soil volume: ~ 250 mc

First of all, the Vermeer MR2000 was used to produce the amount of drilling fluid needed to fill the external storage tank and then, after the full functionality of the system, it was used only to reclaiming fluid and making it available for the drill. During the drilling job were collected some samples of the input and output drilling fluid:

- Max soil content of inlet fluid: 12% (SG=1.2 g/cm^3)
- Max sand content of outlet fluid: 0,25%

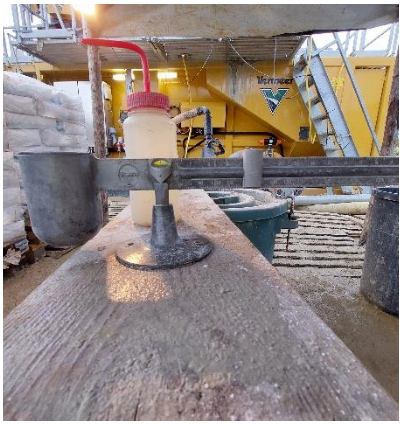

Figure 1. Mud weight – specific gravity (SG)

Figure 2. Sand content

MR2000 benefits:

The MR2000 helped costumer to reduce the amount of drilling fluid volume needed for the job. With an appropriate design of the site area and of the storage tank for the recycled fluid you can control the process like a close circuit. With this type of machine, you don't need to have a specific mixing unit because the structure of the MR2000 help you to recondition the fluid in case you need it.

- Usage of less fluid volume
- Less products needed to prepare fresh fluid,
- Reduced job area: two combined units in only one system,
- Less sound noise level in the jobsite

Figure 3. MR2000 MIXER/RECLAIMER – Preparing the machine in the work area

Figure 4. MR2000 MIXER/RECLAIMER – Preparing the machine in the work area

2.2. VERMEER R500 FULLY ELECTRIC RECLAIMER

This unit was used to manage drilling fluid in a job site in Rovitto Trebisacce (CS) – Calabria – Italy. Main data of the project,

- Customer: Festa S.p.a.
- Day of work: 23
- Installation: Gas distribution
- Pipe material: 16” Steel pipe with 1” polyethylene coating
- Bore length: ~ 330 m
- Bore diameter: ~ 750 mm for 100 m and 550 for 230 m
- External fresh drilling fluid mixing tank volume: 2 x 5 mc
- External mud pit volume: ~ 450 mc
- Drilling fluid: Soda ash, Bentonite and Polymers

Figure 5. Work area

Operational data of the project,

- Number of steps reaming: 4 (16 inches – 30 inches for 100 m – 22 inches for 230 m – 16 inches – 16 inches)
- Theoretical soil volume: ~ 110 mc

Considering the lithology of the jobsite consisting of marly clay from average to high fracturing, sand and silt, it was used a mud motor with bit rock code IADC 537.
The theoretical soil volume to be remove downhole result 110 cubic meter.
The total volume of drilling fluid was 2057 cubic meter of which 495 fresh fluid and 1562 recycled volume.
Without recycling, the entire process is considered as an open circuit, so the total amount of fluid volume and exhaust mud would have been greater; recycling instead, allows to separate solid from drilling fluid and to reutilize it. This can be schematically conceived as a close circuit and the result is that it allows to have a recycling amount of the 76%.

During the drilling job were collected some samples of both drilling fluid recycled and coming from the borehole; the data are collected in table 1:

Table 1. Data of samples collected

Testing	Specific gravity (SG) (g/cm3)	Solid content (%)	Sand content (%)
Borehole	1.09 to 1.12	5.4 to 7.2	2 to 2.40
Recycled	1.06 to 1.10	3.6 to 6	0.5 to 0.75

Figure 6. Mud weight – specific gravity (SG)

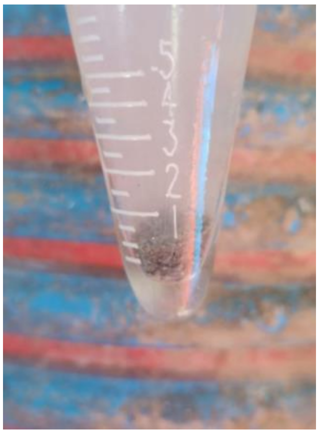

Figure 7. Sand content

The difference between recycling and non-recycling is significant in terms of volume processed, in fact helps customer to reduce the total amount of drilling fluid volume, save water, bentonite, energy, and time while reducing the overall amount of exhaust mud to be disposed.