**Reliable Land Reclamation**  
Efficient, line and operator-friendly drive solution for huge cutter-suction dredger

Schüttgut + bulk solids handling 1/10 + 4/10

When constructing the deep-water port JadeWeserPort in Wilhelmshaven, a cutter-suction dredger is presently being used, which can only be described as the superlative of dredgers. The drive concept is not only extremely reliable and energy efficient, but also exceptionally line friendly – which simplifies the service for the complete suction dredger.

The so-called JadeWeserPort is a deep-water port that is presently being constructed in Wilhelmshaven on the North Sea coast. This deep-water port will be unaffected by the tide. As a consequence, new areas of land are being continually established at the mouth of the Jade River. Three years ago when plans for implementing the JadeWeserPort were firmed up, it became quickly clear: for the huge amounts of earth to be dredged, the existing cutter-suction dredger capacities would not be sufficient to finish the work in the allotted time period. This triggered Bunte, the construction company that had been awarded the order to build the deep-water port, based in Papenburg, Germany to purchase a new “mega dredger”. However, it soon became apparent that the shipyards capable of taking on such a project could not complete the planning and design of such a piece of equipment in the time available. As a consequence, the Bunte Company handled the project themselves.

**Monstrous suction dredger – 100 m long**

Pirat X was created. This is a ship that is a good 100 meters long and 16 meters wide, and in fact it looks more like a floating crane when you see its enormous winch for raising and lowering the suction pipe. In normal operation, the suction pipe is equipped with a cutting head that loosens up the ground. The suction head is driven by a hydraulic motor with a 1 MW rating. The suction equipment has three pumps connected in series. Underwater pump 1 is located at the end of the suction pipe. This has a power demand of approx. 850 kW and is driven by an electric motor. Pump 2 is located at the upper end of the suction pipe and is followed by pump 3; both have a power demand of 1.8 MW and are directly driven by diesel engines. Underwater pump 1 has the task to draw-up the water with the sand that has been loosened by the cutting head and pump this though the suction pipe to pump 2. Pumps 2 and 3 are responsible for transporting the drawn-up sand to the specified dump location. The water-sand mixture with a grain size of 0.3 mm is transported through a 4 km long pipe construction with siphon water intakes and floating pipe 800 mm in diameter. To prevent the sand from being deposited in the pipes, the minimum flow rate of 4.5 m/s must not be fallen below.

**70,000 m³ sand every day**

With a maximum delivery rate of 12,000 m³/h of water-solid mixture, up to 70,000 m³ sand/day is retrieved and hydraulically pumped up. At the end of the project, in about two years, the dredger will have transported 22,000,000 m³. With its cutting head, the dredger can operate down to 32 meters. When operating in deeper water, the cutting head is removed and is replaced by a pipe extension arrangement with hinged joint and vertical suction pipe. This can be used in depths of between 45 m and 50 m. This pipe is equipped with numerous jet nozzles at the end of the suction pipe. Pressurized water is directed towards the bottom through these nozzles to loosen up the ground.

[www.usa.siemens.com/drives](http://www.usa.siemens.com/drives)
Precise and efficient: Variable-speed drive system for suction pump 1

Underwater suction pump 1 is located at the end of the suction line, directly behind the cutting head, and is equipped with a variable-speed drive system. The suction pump can always quickly and precisely adapt itself to the fluctuating grain size of the gravel and the sand. Further, the soft, continuous starting and stopping made possible by the variable-speed operation reduces the stress on the mechanical system of the complete drive train. And last but not least, this concept pays off as a result of its energy efficiency.

With traditional closed-loop control techniques, the motor always operates at the speed designed for the maximum flow rate, and the excess quantity is simply throttled using mechanical actuators – such as throttle flaps. However, with drive systems equipped with frequency converters, the speed, and therefore the energy consumption, is precisely adapted to the actual operating demand – in this case, the grain size distribution of the bulk solids. Put another way, the motor only draws precisely the amount of power that is necessary at any operating point. The energy-saving potential is especially high for fluid-flow machines such as pumps – and depending on the system characteristic, in some cases it can be up to 70%; this is because the power drawn is proportional to the speed to the power of three. The motor of the variable-speed suction pump drive has a rated power of 880 kW at 690 V. This has been specifically designed for underwater operation – in both fresh and seawater – down to depths of 25 m and water temperatures of up to 40 °C. A special three-chamber principle in the terminal box prevents water flooding the complete motor if a cable gland does start to leak. In addition to the usual monitoring elements, such as Pt100 temperature sensors in the windings and bearings, the motor is equipped with various water leakage detectors. Further, anti-condensation heating is absolutely mandatory due to the wet operating environment of the motor.

Sinusoidal current with hardly any harmonics

The motor speed is controlled using a SINAMICS S150 frequency converter from Siemens with a rated power of 1 MW. In order to comply with the regulations of Germanischer Lloyd (GL) acting as supervisory organization in the project, the drive must have a 5% derating in order to take into account the 45°C ambient temperature of the frequency converter. This means that the power yield is 950 kW. The SINAMICS S150 frequency converter has a so-called Active Infeed Module as infeed. The active circuit of the infeed converter is equipped with a clean-power filter. This reduces the harmonic content down to an absolute minimum. The quasi sinusoidal input quantities generated avoid a detrimental additional temperature rise of the onboard generator used for the power supply. On the motor side, the frequency converter is equipped with a voltage limiting filter in order to reduce the level of stress as far as possible on the motor insulation. The complete open-loop control and monitoring is realized via the Profibus DP interface integrated in the converter as standard. The Pt100 temperature sensors in the motor windings and bearings are directly evaluated in the converter using a six-channel evaluation unit. The energy required is provided from a dedicated diesel generator with a rated mechanical power of 954 kW. The generator has 1135 kVA rating with a power factor cos phi of 0.8. This means that a rated power of 908 kW at 690 V is available at the generator terminals. The rated mechanical power of the generator is 949 kW and is therefore harmonized with the rated power of the diesel engine. The generator is also equipped with Pt100 temperature sensors in the windings and the bearings and also has anti-condensation heating. The quasi sinusoidal load generated by the Active Infeed Module of the frequency converter allows the generator to be fully utilized in spite of converter operation. For this project, this converter property meant that a standard 12-cylinder diesel engine was able to be selected that was available at short notice.
Diagnostic functions helped when commissioning

During the “hot phase” of commissioning, it was repeatedly seen that when the dredger pump was operating a full load, the diesel generator speed fell to approx. 1300/min. As a consequence, the frequency decreased down to approx. 43 Hz, the generator voltage controller could no longer follow the load and tended to oscillate. In this state, the frequency converter repeatedly tripped as part of its protective functionality. The cause of what started out to be a puzzling behavior was finally tracked down using the diagnostic functions of the SINAMICS S150 frequency converter. It indicated that the different characteristics of the diesel engine and generator with connected load were the source of the problem. The diesel engine already reaches its rated power of 954 kW at approx. 1300 rpm and at this point, develops the highest torque. The power then remains constant up to approx. 1600 rpm; i.e. the torque decreases approximately continuously from 1300 rpm to 1600 rpm. At 1500 rpm – the most important speed for the generator – it only has 87% of the rated torque. Nevertheless, at 1500 rpm it provides the demanded 954 kW. Finally, the cause for the undesirable speed dips was seen to be that the power requirement of the pump was higher than that specified in the planning phase. It turned out that at full load, the pump demands a motor power of 880 kW; however, according to the rated values and operational specifications due to the efficiency along the transmission section, only 847 kW can be transferred. This discrepancy meant that when the increased load occurred, then the diesel engine operated at the speed where it generates the highest torque – i.e. 1300 rpm.

Selectable power factor

For a low-cost solution to this problem, the SINAMICS S150 frequency converter could fully utilize the strengths of the Active Infeed Module. One of these strengths is also the ability to set the power factor. The rating of the diesel engine was able to be changed from 954 kW to approx. 1100 kW by modifying the injection program. The generator now represented the bottleneck when transmitting the required power. By changing the power factor cos phi from 0.8 to approximately 1.0, the generator could completely supply its apparent power as active power – therefore approx. 1100 kW. With this infeed data, the required power at the motor was reliably reached without the diesel engine speed decreasing. In the meantime, the dredger has been approximately 1 year in operation and the drive system has been operating smoothly without any problems.

Closed-loop speed control simplifies service work

When carrying out service work on the impeller of the suction pump, using the converter it was possible to operate the drive slowly forwards – and what is especially important, also backwards. This turned out to be very advantageous. This meant that the old problem of screw connections that were extremely difficult to release could be elegantly resolved by being able to very slowly rotate the drive – with the bolts firmly held using a suitable retaining device. For this purpose, a specifically designed handheld service operation station is connected to the converter control via a plug-in cable. Auxiliary contacts at the plug-in connection signal the frequency converter that it is in the “repair mode” – and as a consequence, the drive only operates at extremely slow speeds. In part, as a result of the excellent drive solution, the demanding and unique project involving the huge cutter-suction dredger was able to be implemented – with a practical solution and with high energy efficiency. The construction of the JadeWeserPort has progressed considerably as a result of this unique solution.