Nautilus sets out its deep sea mining stall

In an innovation that is set to revolutionise the mining industry Nautilus Minerals is developing a deep sea mineral mining vessel that will exploit mineral deposits at depths of up to 2,500 metres. The Production Support and Storage Vessel is currently under construction and is set to be delivered in the fourth quarter of 2017.

Revolutionary is perhaps an overused adjective, but in the case of the Production Support and Storage Vessel (PSSV) that is currently under construction in China the word is very appropriate. Launch of the vessel will see the start of a new industry, that of the commercial exploitation of deep sea mineral deposits.

Work on the construction of the PSSV has already started at the Mawei Shipyard in Fujian province, China, but the vessel itself is part of an entire mining system that will operate in the Solwara 1 concession off Papua New Guinea (PNG).

The PSSV is an innovative design as the vessel and its mining system are the first of their kind in the world. The ultra-deep water mining process begins at the seafloor where three large mining ROV’s cut rock and turn it into slurry for pumping.

The slurry is pumped to the PSSV via a Subsea Slurry Lift Pump (SSLP) through a top tensioned riser. At the PSSV the slurry is delivered to a Dewatering Plant (DWP) and then into the vessels’ holds for storage. The stored ore is reclaimed from the ship’s holds and offloaded via a cargo handling system into a bulk carrier moored alongside. The bulk carrier then transships the ore to market.

The 227m ship will be constructed with a moonpool through which the SSLP and riser system can be deployed. The three main remotely operated machines consist of an auxiliary cutter that flattens the working site, a bulk cutter that breaks the ore, and a collector that picks up the ore and transfers it through a flexible pipe to the SSLP and then the riser, which takes the ore to the surface.

The DWP separates the ore from the seawater, with the ore being deposited to storage holds while the seawater is returned to the sea depth from which it was first taken to minimise any environmental damage. The DWP brings the moisture content of the ore down to below the TML of the product ensuring the ore can be safely shipped.

Principal project engineer at Nautilus Minerals, Daal Jaffers along with his colleague Mike Howitt, Project Manager Offshore, were responsible for the initial concept designs of the system and this was followed by a preliminary and basic design by Dilip Sarangadh, the technical director at Seatech Solutions International; the detailed and production design was carried out by Mawei Shipbuilding Limited.

A significant number of innovative design features have been incorporated into the PSSV including an advanced power generation and dynamic positioning (DP) system. The DP notation is ABS DPS-2 EHS-F, with system configuration incorporating three engine rooms and a closed ring configuration. The high mining loads, higher than DP requirements, means that there is a special electrical design configuration to allow the sharing of loads between DP and production requirements while keeping the vessel and its assets safe. The closed ring configuration allows a reduction in installed power in the ship whilst meeting the high power demands. This arrangement saves considerable capital cost in the construction of the ship.

In addition, the vessel is designed with a heavy ballast capability that will maintain the freeboard at a constant level, which simplifies the repetitive subsea lifts and side-by-side mooring activities. This simplification translates into improved safety for these operations.

The side-by-side mooring system is a regular operation that will require vessels to moor alongside at sea for a variety of activities, which will take place a number of times a week.
The production support and storage vessel delivers the mining tools to the seabed and ore is collected and sent to the surface via the slurry lift.

Jaffers said: "Simultaneous operations can occur during these times to reduce operational downtime on production. The system is operationally safe for crew to enable line handling, line replacement and line pre-tensioning and monitoring during the operations."

Mooring events that occur at sea are for ore offload, bunkering, re-victualling, crew transfer, garbage removal, line transfer, miscellaneous liquids removal and sparging.

In total the PSSV can accommodate 199 crew and meets the Special Purpose Ships (SPS) code and also the Maritime Labour Convention 2006. In addition, it has a central control room to enable seamless subsea and deck operations. All control stations are within one room for ease of communication and to improve production efficiencies.

It also features a wide range of technologies and equipment to facilitate its operation such as seabed mineral extraction topsides support equipment, extensive equipment integration and support systems for ore production, and a survey system. The vessel will house the subsea mining tools with support mechanisms such as launch, recovery, subsea operation and maintenance. The subsea tools are the three large ROVs being used as Seafloor Production Tools (SPTs). These are large tracked vehicles used for mineral ore production on the seafloor.

The three SPTs are:
- Bulk Cutter (BC) – the configuration is similar to a continuous miner. This is a high production rate machine that does the bulk of the production cutting
- Auxiliary Cutter (AC) – the configuration similar to a tunnelling roadheader with contra-rotating, dual cutting heads. This is an agile machine that prepares the mine site and completes production cutting
- Collecting Machine (CM) – the configuration is similar to a crawler cutter suction dredge. This collects the cut material from the seafloor stockpile, fluidises it into pumpable slurry and also acts as a charge pump for the SSLP to pump the slurry to the surface vessel for dewatering, storage and offload.

A deck mounted derrick is used to lift and lower the SSLP and the riser. It has a similar configuration to a drill derrick without the rotating turntable. This is part of the riser retrieval and running system. In addition, the ship is equipped with:
- A SSLP with a configuration similar to an ultra-deep water mud pump starting to see use in dual gradient drilling. This is a dual bank diaphragm pump. Power is transferred to the diaphragms via high pressure water injected from the surface ship
- Riser handling system – uses a gantry crane, catwalk and horizontally stacked riser joints. The system handles riser joints into and out of the derrick
- Riser hang off structure sits on top of the moonpool below the derrick to hold the SSLP on deck for maintenance and also to hang the deployed riser system from the vessel.

The cargo handling system is a configuration of belt conveyors, rotating stackers, scoop, scraper conveyors, vertical bucket elevators, and telescopic offloading arms. It handles dry ore from the dewatering plant and distributes it into four cargo holds. The system trims the ore to meet the requirements of the International Maritime Solid Bulk Cargoes Code (IMSB Code) and also meets T1I requirements from the same code. "The ore is very dense with specific gravities of up to 3.81t/m³ and bulk densities at a little over 20t/m³. So the material is more dense than most bulk cargoes seen in the market. The utilisation of the cargo holds is very high with the stack of the ore extremely important to be able to utilise space. Many studies were undertaken to arrive at the preferred solution that is being installed in the vessel for the cargo handling. The cargo holds can essentially be reclassified clean with little manual intervention. This saves manual labour for cleaning out and inspecting coatings in the holds."

The material is highly abrasive so it is important that material selection for equipment in the holds is of the utmost importance. Cargo hold strengths due to high bulk densities was also considered. In addition, the large cargo hold spans with high deck loads from equipment above requires high end structural analysis with load combinations for operation and survival to be considered. The result is a self-contained loading and unloading system with low maintenance requirements that has a fully remote controlled operation to ensure seamless bulk cargo storage and handling, explains Jaffers.

Deck stiffness on the ship is also of utmost importance with deflection across operating equipment needing to be met. The ship's deck arrangement is busy with topsides equipment arranged to improve operational efficiency and maximise productivity.

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0A Plan for the Production Support and Storage Vessel