A design overview of

Manson Construction's latest trailing suction hopper dredge, *FREDERICK PAUP*

An operator's investment in a new hopper dredge is a long-term commitment to a complex vessel working in an abrasive environment. Even with those headwinds, anticipated life cycle durations for modern US flagged dredges typically need to exceed 50 years with minimal downtime to achieve successful capital investment returns. Designed by Manson Construction Co. and Hockema Group (Hockema), the trailing suction hopper dredge (TH) GLENN EDWARDS has been a leading performer in the dredging industry over the past 15 years and set the trend for modern operators building large hopper capacity flagships as fundamental assets for their dredging fleets.

The delivery and observed success of the GLENN EDWARDS (hopper capacity of 13,700 yd^3) was followed by the construction of the hopper dredge MAGDALEN (hopper capacity of 8,550 yd^3) and the articulated tug-barge ELLIS ISLAND (hopper capacity of 14,800 yd^3), both delivered in 2017. With the dredging market demands continuing to outpace the existing US fleet capacities, Manson realized a new opportunity to strengthen their fleet with an advanced, high capacity TH design resulting in their latest addition, the FREDERICK PAUP.

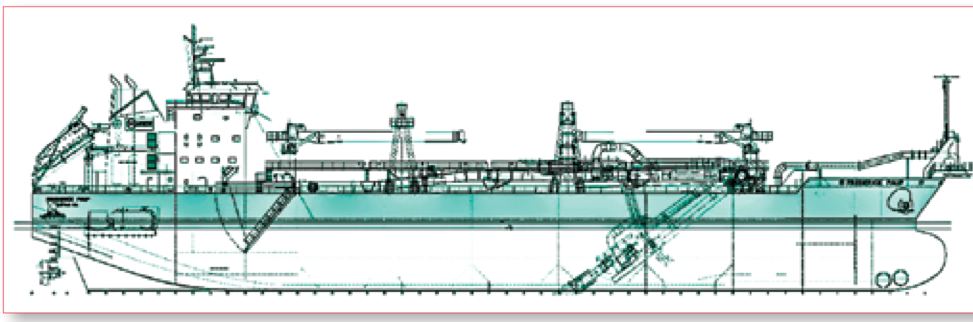

Figure 1: FREDERICK PAUP Outboard Profile

Scheduled to begin service in the spring of 2023, the FREDERICK PAUP will be the largest US-flagged, self-propelled hopper dredge delivered in this country's shipbuilding history. Once again collaborating with the naval architects at Hockema, the 419'-10" Length Overall x 81' Wide x 32'-6" Deep (to Main Deck) vessel boasts a hopper capacity of over 15,000 yd^3, surpassing her predecessors, the afore mentioned ELLIS ISLAND and GLENN EDWARDS. The vessel is currently under construction at the Keppel AmFELS shipyard in Brownsville, Texas and will receive ABS XA1, XAMS, and ACCU class notations as well as SOLAS certification once completed. The vessel will be propelled by (3) stern Z-drive units and has (2) bow thrusters forward.

As part of the design process, Hockema has developed a signature hopper dredge hull form and arrangement combination to maximize the ratio of hopper capacity versus cubic hull dimensions. The bow and stern hull lines of the FREDERICK PAUP were developed to reduce bare hull resistance in both the loaded and unloaded conditions using Computational Fluid Dynamic (CFD) analysis. The CFD validation was critical in ensuring Hockema's goal to achieve a high-capacity vessel with restricted overall hull dimensions while meeting target steaming speeds.

Modifications to the hull form reduced calm water resistance from the initial baseline form approximately 18% in the loaded condition and 11% in the unloaded condition. Flow was also evaluated over the stern skegs and z-drive pods, entering and exiting the Z-drive nozzles and over the bow thruster tunnels. The bow thruster tunnel grating alignment was adjusted to reduce resistance and the aft appendages leading flow into the z-drive legs were adjusted to reduce the streamline turbidity in those locations. Modifications to the appendages from the initial design reduced calm water appended resistance approximately 8% in the loaded condition and 10% in the unloaded condition.

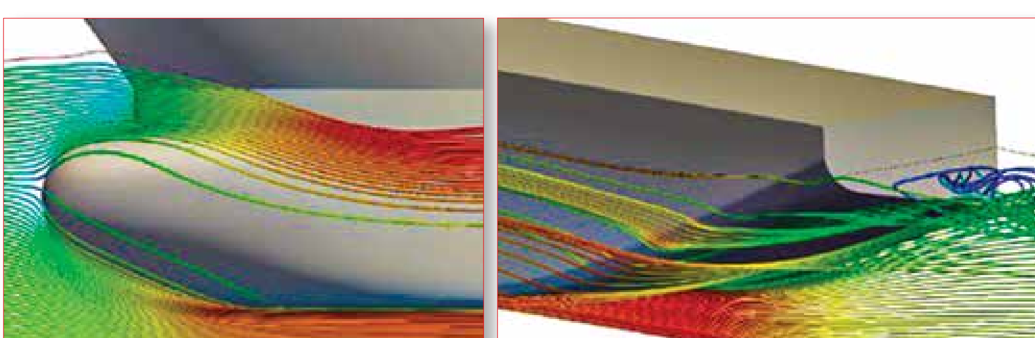

Figure 2: Bow and Stern Streamlines from the CFD Evaluation

The dredging system that supports the loading and emptying of the hopper volume includes dual dragarms deployed at the upper working deck level, five (5) pairs of dump doors located at the bottom of the hopper, and a bow coupling unit which can be connected to a floating discharge hose for long range distribution of spoils or by "rainbowing" hopper contents through a high pressure rated nozzle fitting. Drawing from their 115 years of marine operations experience, Manson's engineering team has custom-designed the dredging equipment to meet this vessel's industry-leading performance requirements while still integrating their fleet operational and maintenance standards.

The hopper shape includes a sloped bottom in the lower part as well as four (4) moguls running the breadth of the hopper which are evenly spaced over the hopper length. Coupled with the ability of the jet water system's numerous nozzles to create a spoils slurry within the hopper, these sloped surfaces direct hopper contents to the dump door bays between the moguls either for release through the doors or pump-off by suction bell-mouths leading to a common pump-off manifold. Other than these pump-off branch suctions and the jet water system nozzles, all other dredging system piping is arranged outside of the hopper volume to reduce weather and spoils exposure as well as maximize the hopper volume capacity.

With fully automated systems, all vessel navigation and dredging operations can be executed from the pilot house located at the top of the superstructure in the after portion of the vessel, just forward of the engine room and exhaust stacks. The entire working deck, hopper loading chute, spoils level control weirs, dump door cylinders, and the above-deck portion of the pump-off system can be viewed from the drag-tender's station at the forward end of the pilot house. The mate's navigating station is directly aft and higher than the drag-tender, providing 360-degree visibility necessary for operations in busy shipping channels, also providing for overall vision of dredging operations and direct verbal communication with the drag-tender. Vessel maneuvering during dredging operations is via a dynamic positioning system allowing for a precise track for the twin drag-heads.

The pump and motor rooms supporting the pump-off and jet water systems are arranged forward of the hopper boundary near the vessel's bottom shell. The "wet" equipment, such as the large pump-off pumps, jet water pumps, and suction manifold piping, is isolated from the pumps' associated electric drive motors, switchboards, and other electrical equipment by a full hull depth watertight transverse bulkhead. Given such large equipment items and system pipe diameters, Hockema's designers modeled the entire pump room and pump-off suction manifold in 3D to efficiently arrange this tight space while maintaining equipment and fitting maintenance access needs. Clearance above the pumps was maintained all the way up to the vessel's weather deck via large, bolted hatches allowing for direct crane lifting access. This facilitates fast turnarounds for equipment and system fitting removals.

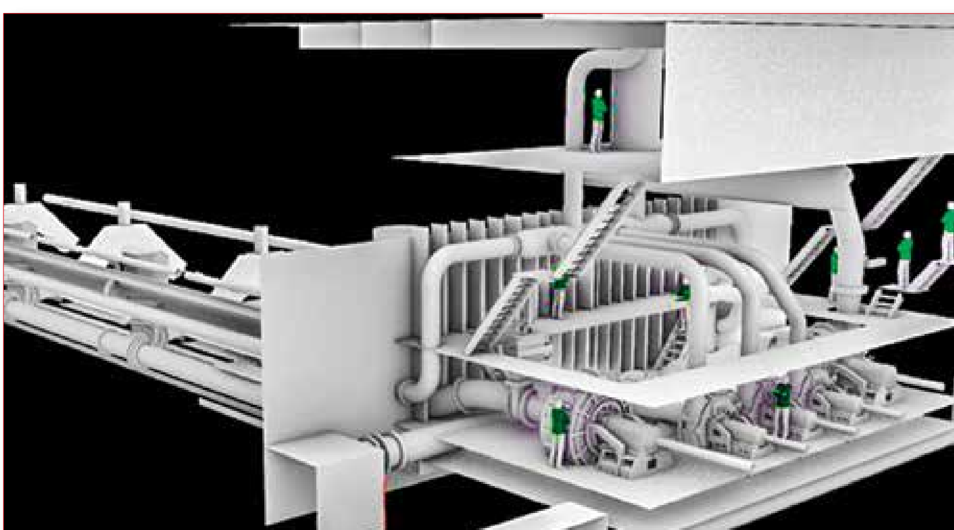

Figure 3: 3D Model of Pump Room and Suction Manifold

Many hopper dredge designs locate drag arms in a recessed well deck area on either side of the hopper to stow them nearer the water surface. In that arrangement, the drag arms still require a hoisting and/or vertical trunnion track system for deployment. Originally developed by Manson and Hockema on the GLENN EDWARDS, the continuous upper working deck (01 Level) on the FREDERICK PAUP runs the length of the hopper offering the following advantages:

Optimal hull girder strength performance – Including this upper working deck in the vessel's hull girder section takes full advantage of the hull and hopper depth increasing allowable vessel bending moments when loaded with spoils. The hopper coaming itself also no longer becomes integral to hull girder strength and can be more economically constructed. Continuous working deck in way of all dredging equipment – The drag arms, associated winches and davits, trunnions, and bow discharge coupling unit can all be serviced at the same deck level. This arrangement avoids weather deck stair transits during dredging system installation, testing, and servicing and provides safer access to the drag-arm components when the vessel is underway. Weather protected, interior passageway surrounding the hopper – Between the 01 Level and Main Deck, a completely enclosed passageway spans the length of the hopper for crew transit, routing of bow to stern cable-ways, and additional accessible equipment installations.

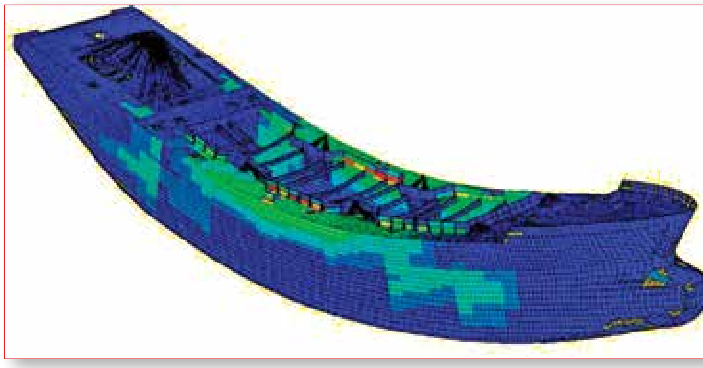

Figure 4: Finite Element Analysis model of the FREDERICK PAUP hull girder strength evaluation

The aft deck house arrangement of the FREDERICK PAUP also better concentrates those spaces of higher occupancy because the pilot house, accommodations, and engine room are all aft of the hopper. This consolidation of personnel spaces reduces crew walking distances, simplifies HVAC and ventilation systems, and minimizes wire-ways and piping spanning the full vessel length. The aft deck house coupled with protected passageways below the working deck offer efficient paths for personnel movements about the vessel. The crew can more quickly reach positions of operational readiness with reduced daily fatigue. With these and additional arrangement features, the FREDERICK PAUP design takes advantage of the hopper-hull interface to achieve the most compact vessel size practicable translating directly into construction cost savings.

Driving this advanced vessel is a fully centralized diesel-electric power plant providing a high level of versatility in terms of equipment location, arrangement, and redundancy – a key to significantly increased reliability. This system allows for improved power management by matching the generated power to the specific operational mode. Benefits include less fuel consumption, single engine room and exhaust piping arrangement, lower operating hours across the entire engine compliment, and reduced carbon emissions.

With five (5) EPA Tier-IV compliant generator sets configured in parallel, the FREDERICK PAUP is capable of continuous operations at near-peak performance levels even when a generator is taken off-line. This type of powering scheme is, however, equipment-intense electrically considering the number of switchboards, transformers, variable frequency drives, and motor controllers required. With space constraints inherent to the efficient overall hull dimensions, Hockema's electrical engineers strategically grouped electrical systems into varying operating voltage categories to allow for the selection of more compact electrical equipment, minimizing their arrangement footprints.

Collaboration between the owner and naval architects was a key component to the success of the FREDERICK PAUP new construction program from the beginning. Starting with a proven vessel concept in the GLENN EDWARDS, this latest engineering effort blends Manson's deep experience in US-based dredging operations with Hockema's hopper dredge design capabilities and US and international regulatory expertise. The resulting design advances hopper dredge technology in the areas of hull size efficiency, dredging equipment automation, safety features, and powering versatility. The FREDERICK PAUP is anticipated to become the industry benchmark for large capacity dredge vessels upon entering service in 2023 as operators continue to expand their fleets to meet the mounting needs of America's ports and waterways.

www.mansonconstruction.com, www.hockema.com,

See ad on pg. 13 ❍