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THRUSTERS AND DRIVE SYSTEMS

Dynamic Positioning System for A Crane Barge

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Summary

This paper describes the conversion of a flat top barge into a dynamically positioned crane and pipe laying barge. The conversion was made under the heading "Make it as simple and effective as possible". So DP is possible by no. 4 deck-mounted direct Diesel driven SCHOTTEL Rudderpropellers and fixed pitch propellers.

Position control is based only on DGPS and special dynamic positioning programs to compensate the lack of propeller rpm control between 0 and low idling speed of Diesel engines.

Background

P. W. Resources/Kent Resources is a construction company operating for more than 15 years in Nigeria, especially for the oil industry. As also there a trend towards offshore activities is seen, the company decided to purchase a used pontoon type barge and converted it locally into a crane and pipe-laying barge.

Technical data of the barge (fig. 1):

Length over deck	76.00 m
Length of waterline:	75.00 m
Breadth moulded:	24.00 m

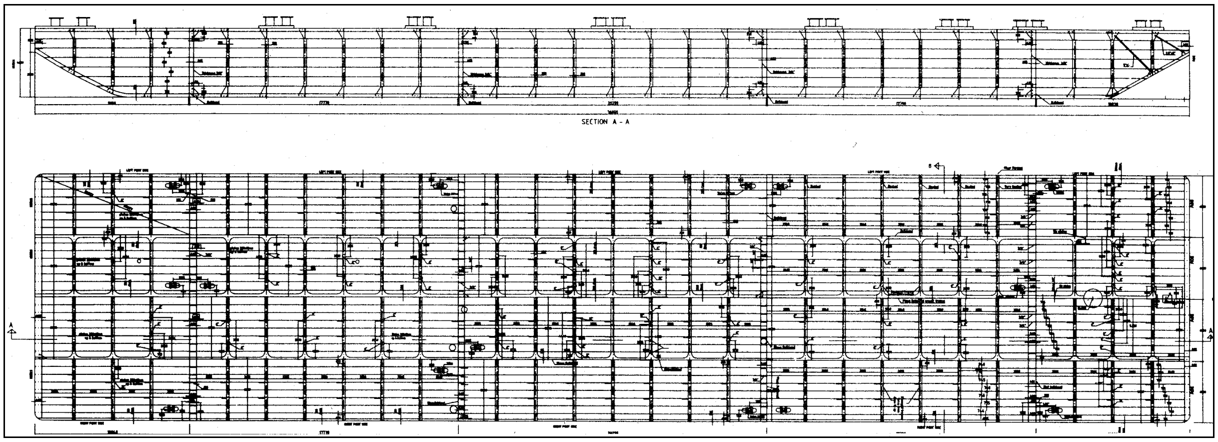

Fig. 1

Draft	Corresponding displacement	Dead Weight
1.25 m	2000 t	
1.90 m	3000 t	1000 t
2.50 m	4000 t	2000 t

The barge had basically no equipment at all on board and for the new task it was equipped with:

- 1 crane Manitowoc type 888, SWL 200 t
- 500 m^2 deck area for cargo pipes etc.
- 1 accommodation block for 20 persons with all necessary equipment and wheelhouse on top

Technical considerations and solutions

The customer decided at an early stage on 4 thrusters to provide the self-propulsion and the dynamic positioning, but location and power of the thrusters was discussed.

A Kongsberg Simrad DP system was also chosen by the customer very early, but a turnkey project providing propulsion and DP as well as the general lay outs for all arrangements on board was the brief of the owner.

After common discussions with the owner and Simrad, SCHOTTEL worked out several propulsion/power calculations under the heading “What will be the max. transverse current for DP under wind conditions up to Beaufort 7”.

Under these conditions transverse currents could be compensated between 1.3 and 2.0 kn at the different displacements within a motorization 4 x 340 kW to 4 x 480 kW.

Due to practical reasons, the size of barge and the displacement, and due to the Caterpillar Diesel engines preferred by the owner, the final selection was to use an installation of 4 x 358 kW in connection with Caterpillar 3408 Diesel engines, radiator cooled.

The units are installed in form of deck-mounted equipment as a SCHOTTEL Navigator with motor canopy, shafting, Diesel engine and thrusters type SCHOTTEL Rudderpropeller SRP 200, reduction 3.44 : 1, propeller diameter 1200 mm with nozzle *(figs. 2 a, 2 b and 3)*.

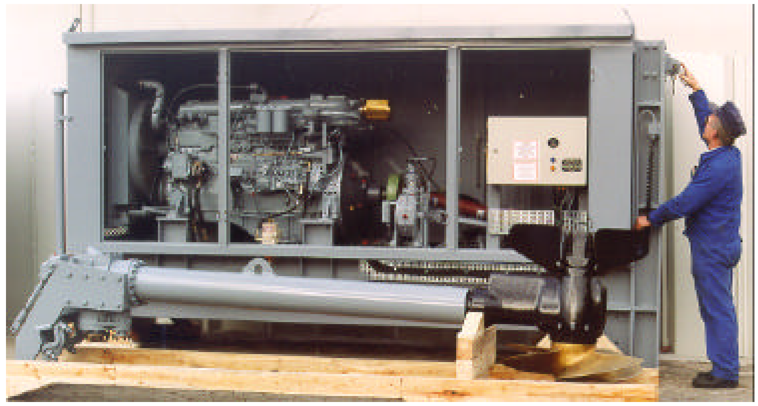

Fig. 2 a

Fig. 2 b

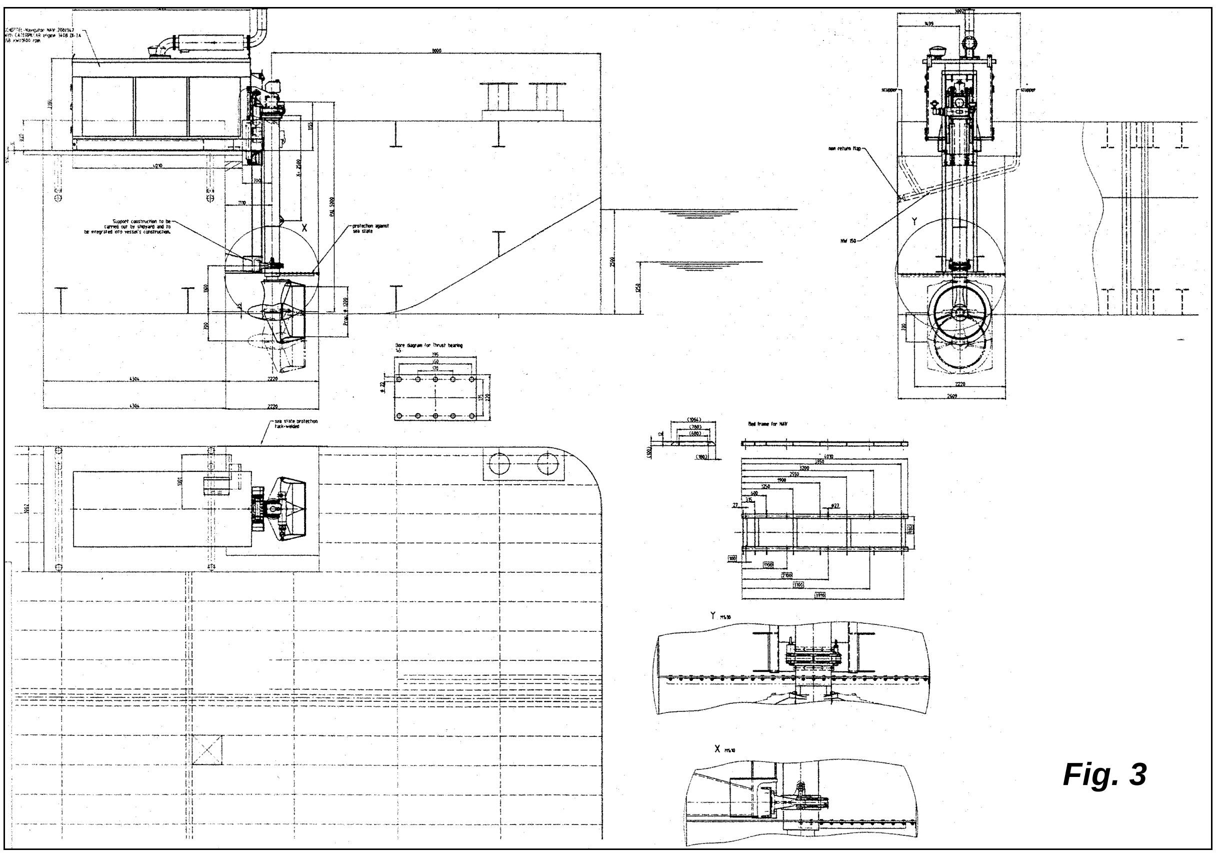

Fig. 3

The max. static thrust of 1 unit is 57 kN (6 t).

Special attention was given to the arrangement of thrusters. Of course, for optimum manoeuvrability and thrust force levers, the best position for the thrusters would be for the very forward and rear end of the barge hanging over bow and stern.

This position, however, has the disadvantage that the reach of the crane is limited and in sea state the propellers are exposed to suck air or green water can cause damage to the motor housing.

Therefore a position at the sides of the barge (9 m from the ends) was selected, and the thrusters were installed into side recesses to keep the breadth of barge for docking and berthing purposes.

After this clarification the new general arrangement of barge was possible to design *(fig. 4)*
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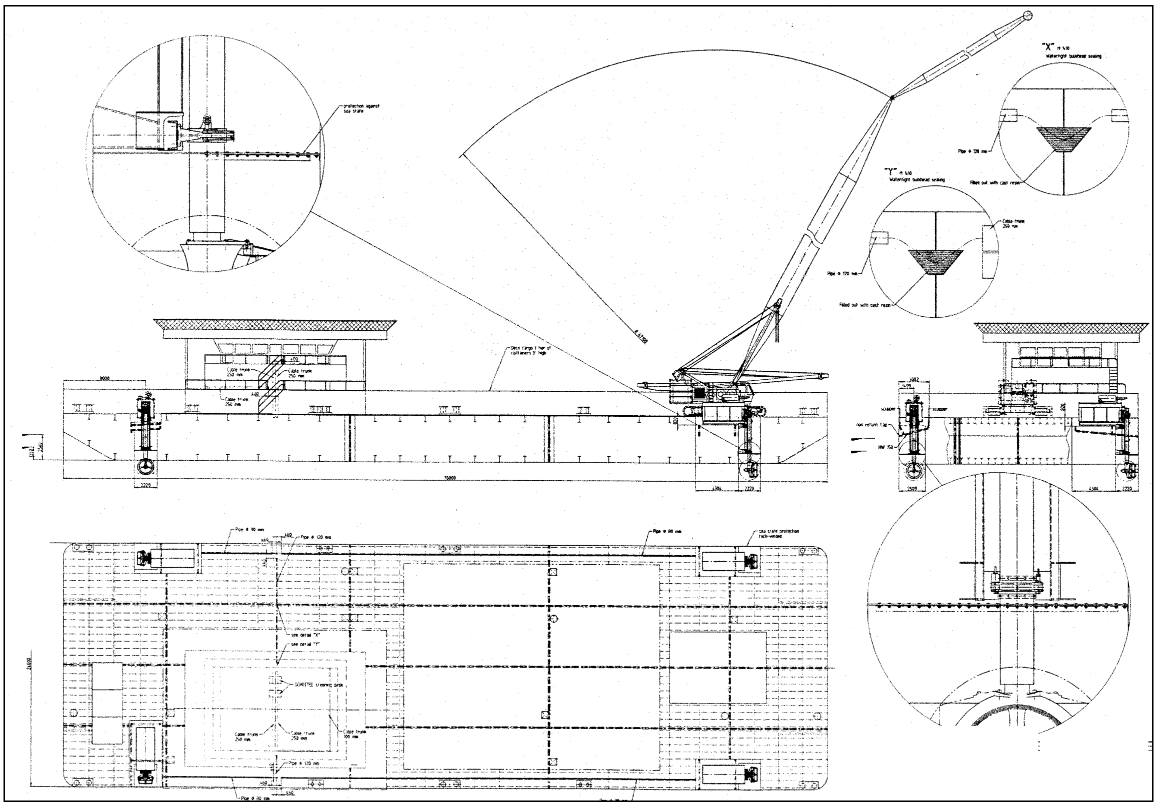

Fig. 4

Dynamic Positioning Arrangement and Effects

For the final position of thruster and the selected arrangement of accomodation and wheelhouse, possible deck loads and crane operation, Kongsberg Simrad made the final dynamic positioning performance calculation resulting in the following:

Displacement (t)	Current (kn)	Max. wind force (beaufort)
2000	1.0	7
2000	3.0	6
4000	1.0	9
4000	2.0	7

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The DP system considers the basic thrust of the units as per polar diagram of forces *(fig. 5)* and has to avoid a negative interaction by one thruster blowing into the other so that critical angles for negative interference between the thrusters are blocked for the DP operation *(fig. 6)*.

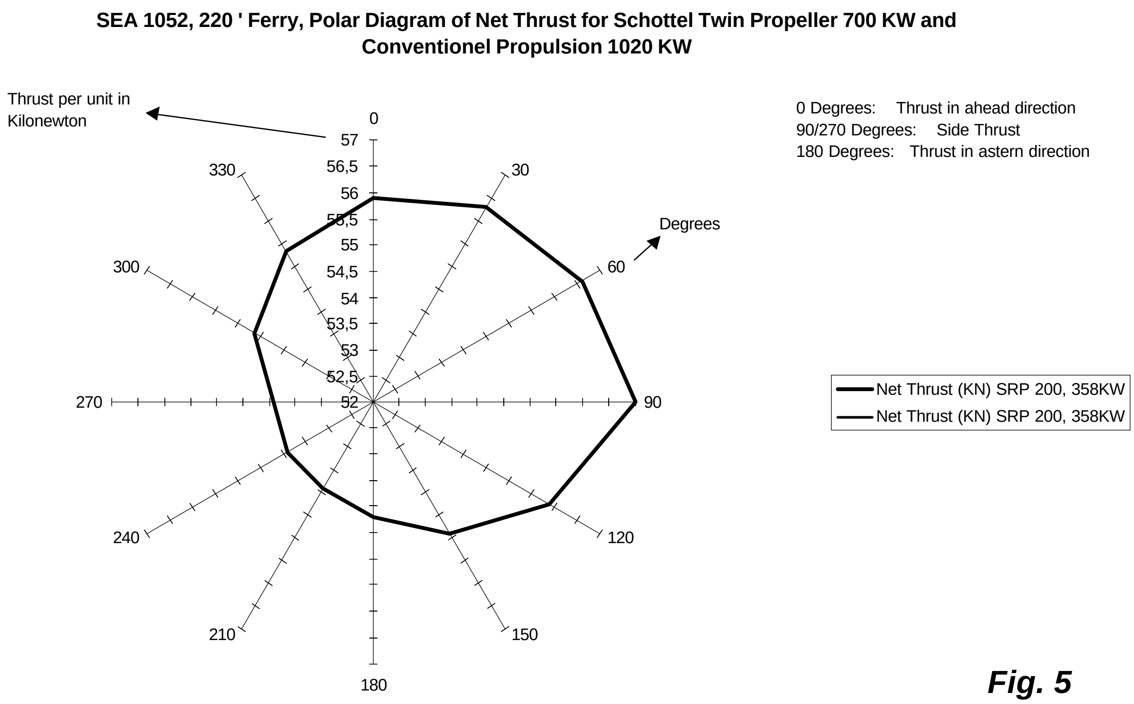


Fig. 5

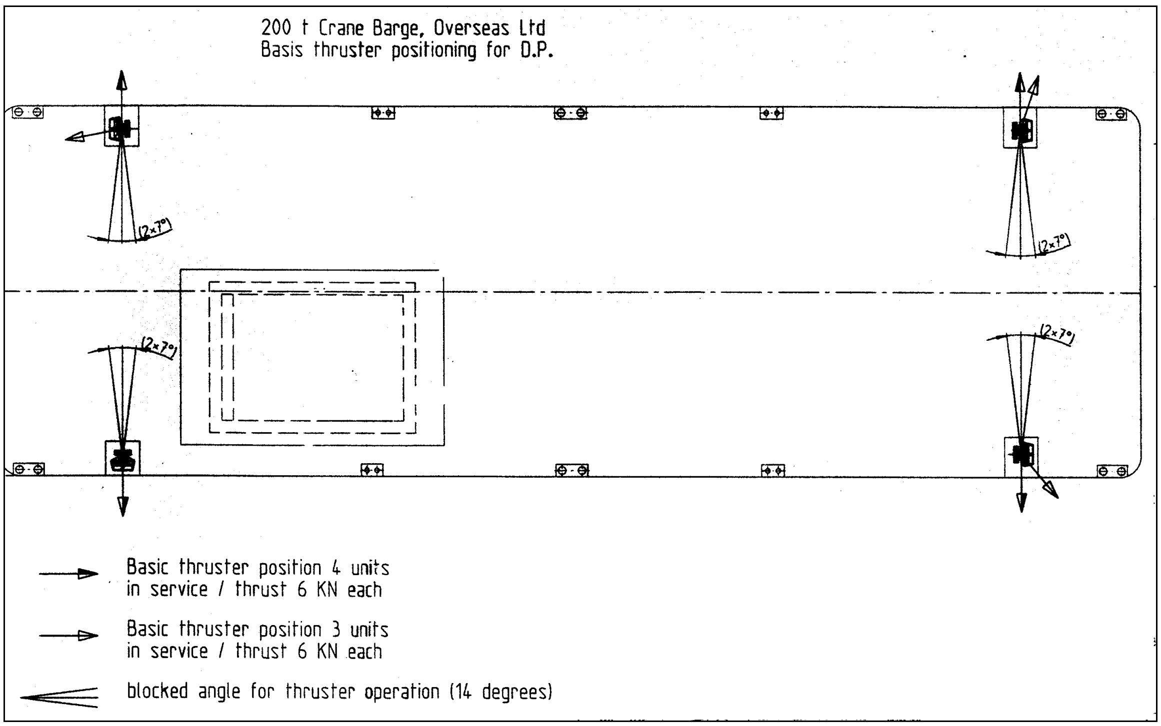


Fig. 6

As the thrusters are controlled down to the low idling speed of engine, which is 600 rpm, and no disengaging and declutching of the engines is foreseen during DP operation, a basic low thrust position is foreseen as per fig. 6, where the two opposite thrusters compensate their thrust at low idling rpm of engine.

This lowest thrust, however, is only 11 % of the max. thrust.

A. m. thrust direction is the basic thruster position for DP and all further manoeuvres are carried out by alteration of azimuth angle and rpm increase by one, two, three or more thrusters.

This configuration avoids the thrusters being engaged and disengaged frequently, so additional wear on clutches, gears and motors is completely avoided. This system has also to work when only three or two thrusters are in service.

The critical situation is when 3 thrusters are in service. Then basic thruster position has to be as per fig. 6. also here three thrusters are compensating each other's thrust at low idling speed of engine.

Engine Performance under Part Load Condition

As the full power of barge for dynamic positioning was selected to keep the position under severe condition, i.e. wind around beaufort 7 and current up to 3.0 m/sec. (5 kn) it is expected that under normal/average working conditions the engines are operating continuously at comparatively low rpm and low load.

The engine manufacturer have to face this problem and have to design the engine to this condition. The problem was discussed with Caterpillar for the engine 3508 and the following statement was given**:**

Engine Slobbering

Extended engine operation at no load or lightly loaded conditions (less than 15% load) may result in exhaust manifold slobber. Exhaust manifold slobber is the black oily fluid that can leak from exhaust manifold joints. The presence of exhaust manifold slobber does not necessarily indicate an engine problem. Engines are designed to operate at loaded conditions. At no load or lightly loaded conditions, the sealing capability or function of some internal engine components may be adversely affected. Exhaust manifold slobber is not usually harmful to the engine, but the results can be unsightly and objectionable in some cases.

Exhaust manifold slobber consist of fuel and/or oil mixed with soot from the inside of the exhaust manifold. Common sources of oil slobber are valve guides, piston rings and turbocharger seals. Fuel slobber usually occurs with a lack of, or incomplete, or inconsistent combustion.

A normally operating engine should be expected to run for at least one hour at light loads without significant slobber. Some engines may run for as long as three, four, or more hours *before slobbering, however, all engines will eventually slobber if run at light loads. External signs of slobber will be evident unless the exhaust system is completely sealed.*

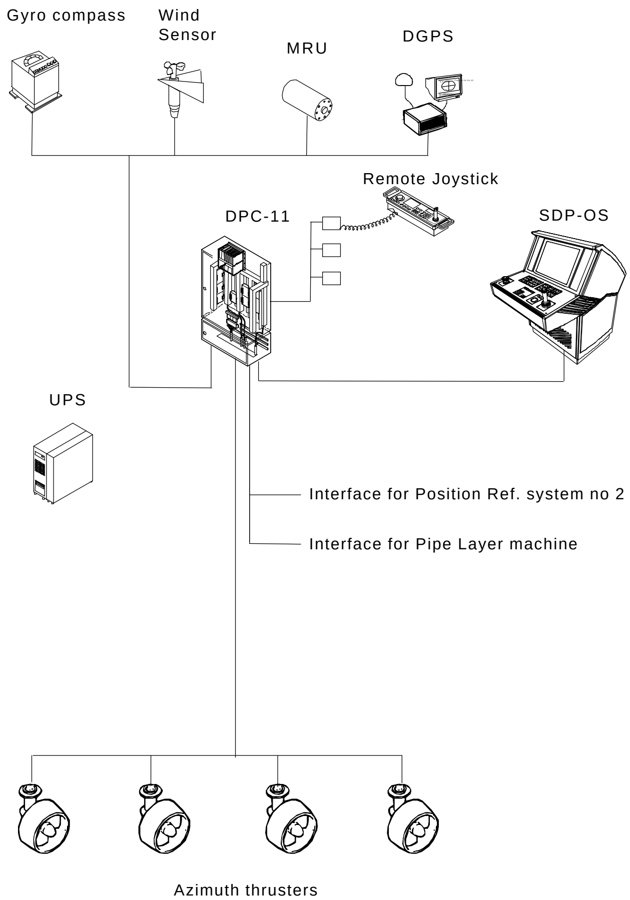
If extended idle or slightly loaded periods of engine operation are mandatory, the objectionable effects of the engine slobber can be avoided by loading the engine to at least 30% load for approximately ten minutes every four hours. This will remove any fluids that have accumulated in the exhaust manifold. To minimize exhaust manifold slobber, it is important that the engine is correctly sized for each application.

So this advice to load the engines every four hours will be observed by the customer, as the crane operations are anyhow limited in time. For pipe laying the average load of the engines is higher because a constant tension has to be provided to the pipe.

Dynamic Positioning Hardware and Software

The owner’s choice for hardware and software was Kongsberg Simrad, and the initial installation is the minimum to be foreseen for crane operation. The system consists of a DGPS differential positioning system with Inmarsat B demodulator, Narda Coupler and the software from the system is interfacing to giro compass, motion reference unit, wind sensor, thruster interface and pipe-laying machine interface.

An operator panel is installed in the wheelhouse, there all modes, reference systems, sensors etc. can be selected (fig. 7).



Modes and functions:

- **Manual Joystick**
- **Auto Heading**
- **Auto Positioning**
- **Auto Track mode**
- **Pipe laying**
- **Controller gain selection**
- **Selection Rotation Point**
- **Selection of Display Presentation**
- **Extended Navigation compensation**
- **Draught compensation**
- **Quick model update**

Fig. 7

Basic principles:

A sea going vessel is subject to wind, wave and current forces. Wind speed and direction are measured by the Wind Sensor. The vessel's response to wave and current forces is sensed, and the thrust required to counteract these forces is accurately calculated.

The DP system controls the vessel's motion in the three horizontal degrees of freedom – SURGE, SWAY and YAW. Vessel movements are measured by the Gyro Compass and the position reference systems. Reference system readings are corrected for roll and pitch using readings from the Vertical Reference Sensor.

Mathematical modelling and Kalman filtering techniques improve noise filtering of all measurements, which reduces thruster modulation and wear.

- *Optimum controller and wind feed forward signals assure accurate positioning*
- *Mathematical modelling provides dead reckoning control mode*
- *Ease of operation*
- *Simultaneous use of all position reference systems with weighting for optimum combination*
- *Built-in simulator for off-online training and operational planning*