Trailer Hopper Suction Dredgers Developments in the Low lands

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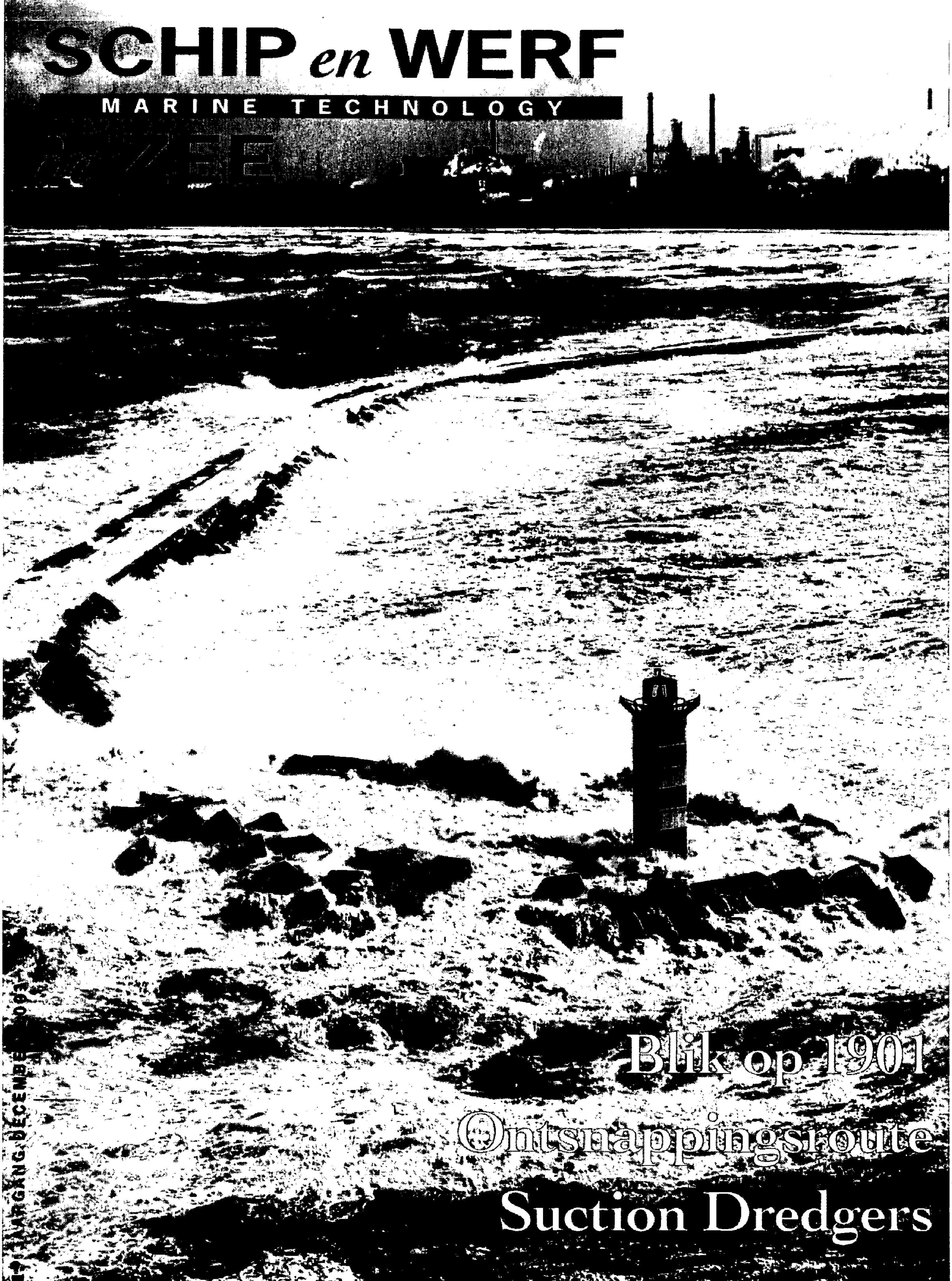

Uitgelicht

8

DE ZEE
ZEEVAARTKUNDIG TIJDSCHRIFT

Blik op 1901
Een overzicht van de maritieme zaken die honderd jaar geleden speelden. Geselecteerd uit het Nautisch Technisch Tijdschrift (NTT) "De Zee"

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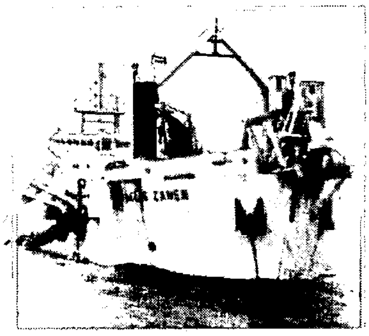
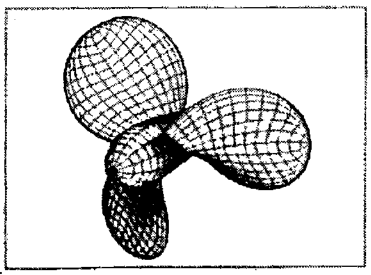


Trailer Hopper Suction Dredgers developments in the Low Lands
The main players are mentioned along with some design data of existing vessels and trends. New developments are brought to light. A large Trailer Hopper Suction Dredger, (THSD) "Vasco da Gama" recently delivered is discussed in detail.

41



Omstromingsberekeningen rondom een schroef
Het laboratorium Scheepshydromechanica van de afdeling Maritieme Techniek van de TU-Delft heeft een rekenprogramma ontwikkeld, dat omstromingen van (ondergedompelde) lichamen in een rotatievrije stroming berekent. De berekeningen zijn gebaseerd op een panelen methode.

Inhoud

2 **Nieuws**

6 **De Maritieme Markt**
Helaas, een waakzame Kerst

8 **Blik op 1901**
Onze eindejaarsrubriek: een overzicht van de maritieme zaken die honderd jaar geleden speelden

14 **Trailer Hopper Suction Dredgers developments in the Low Lands**

22 **Maand Maritiem**

27 **Major Mobdock work done on Saipem 7000**

30 **Poriën ballastcoating**
Bij het Centrum voor Onderzoek en Technisch advies BV (COT) werd gevraagd of het aangebrachte verfsysteem in waterballasttanks conform bestek is aangebracht.

33 **Productinformatie**

36 **A microscopic model for simulating mustering and evacuation processes onboard passenger ships**
The analysis of evacuation processes onboard passenger ships has attracted increasing interest over the last years. In this paper a simple Cellular Automata (CA)-model for the description of crowd motion is presented and its implementation in a simulation software outlined.

41 **Omstromingsberekeningen rondom een schroef**

45 **Literatuuropgave**

48 **Verenigingsnieuws**
Nieuws van KNVTS, HME en VNSI

54 **Agenda**

55 **Maritime Search**

Bij de voorplaat: Havenmgang IJmuiden met op de achtergrond de Hoogovens (Foto Flying Focus)

Trailer Hopper Suction Dredgers developments in the Low Lands

A description is given of the Trailer Hopper Suction Dredgers developments in the Low lands. The main players are mentioned along with some design data of existing vessels and trends therein. New developments are brought to light. A large Trailer Hopper Suction Dredger (THSD) "Vasco da Gama" recently delivered is discussed in detail.

Introduction

One of the things we do well in the Low Lands is building dykes and reclaiming land. In order to do this our ancestors learnt how to dig out earth material from (just) underneath the water surface and transport it to a strategic position where it served as a dyke to prevent flooding and save peoples lives; thus making life possible for next generations to come and laying the seeds for our present prosperity. Yet another reason for doing this was also the building of canals, a water highway on (and through) which many people and goods could be easily transported from one town to another.

Indeed we have evolved a far way from the man with a medieval wooden spade to their present counterpart the trailer hopper suction dredgers of today.

Trailer Hopper Suction Dredger

A typical trailer hopper suction dredger is shown in Figure 1. The normal working cycle of this type of vessel can be broken down into four basic functions:

- Winning material from below the water surface
- Containment of the material
- Transporting the material to another location
- Discharging the material
- Sailing back empty to the winning area
- Repeat this cycle endlessly (if need be)

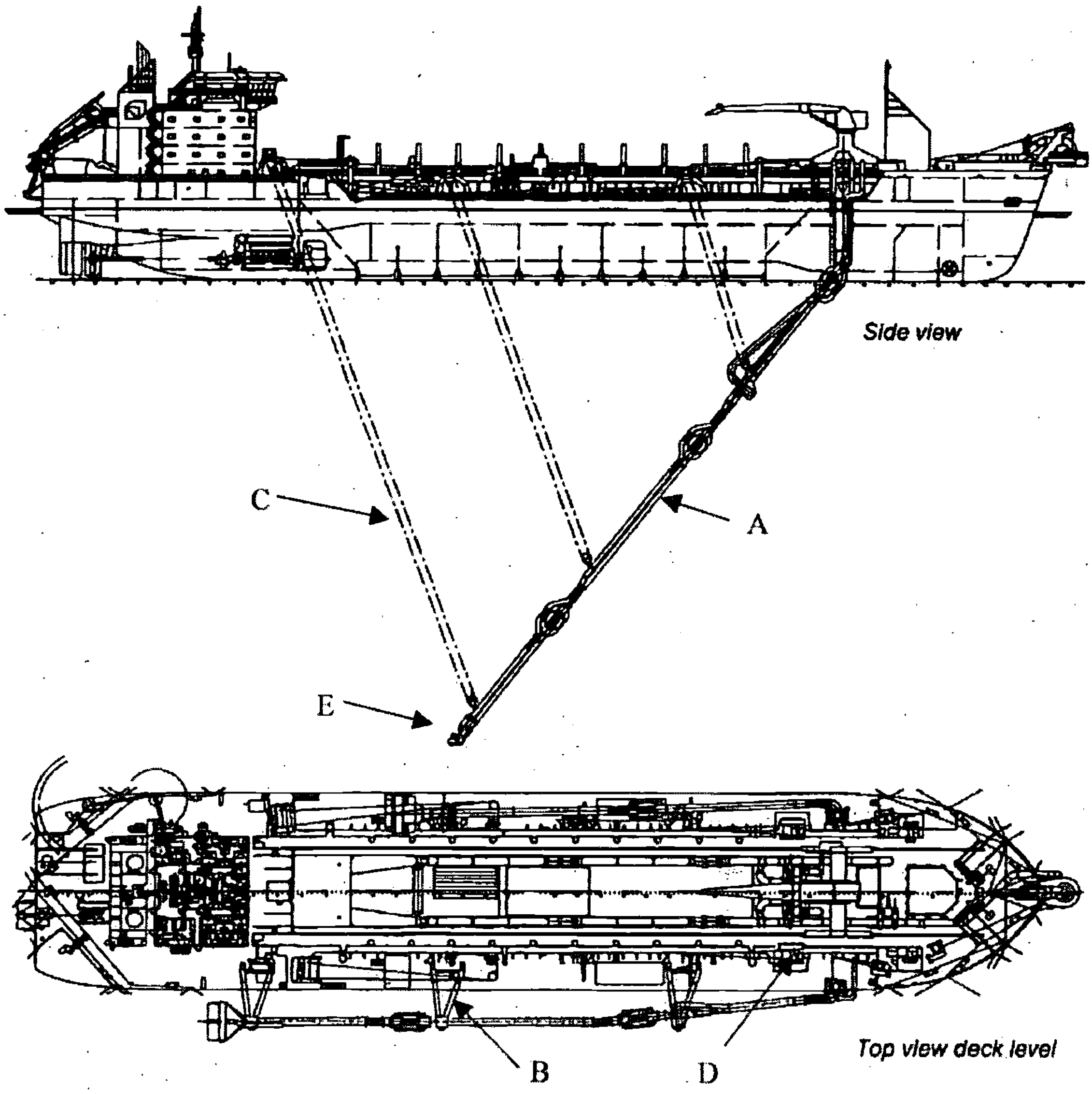


Figure 1. General arrangement plan of trailer suction hopper dredger

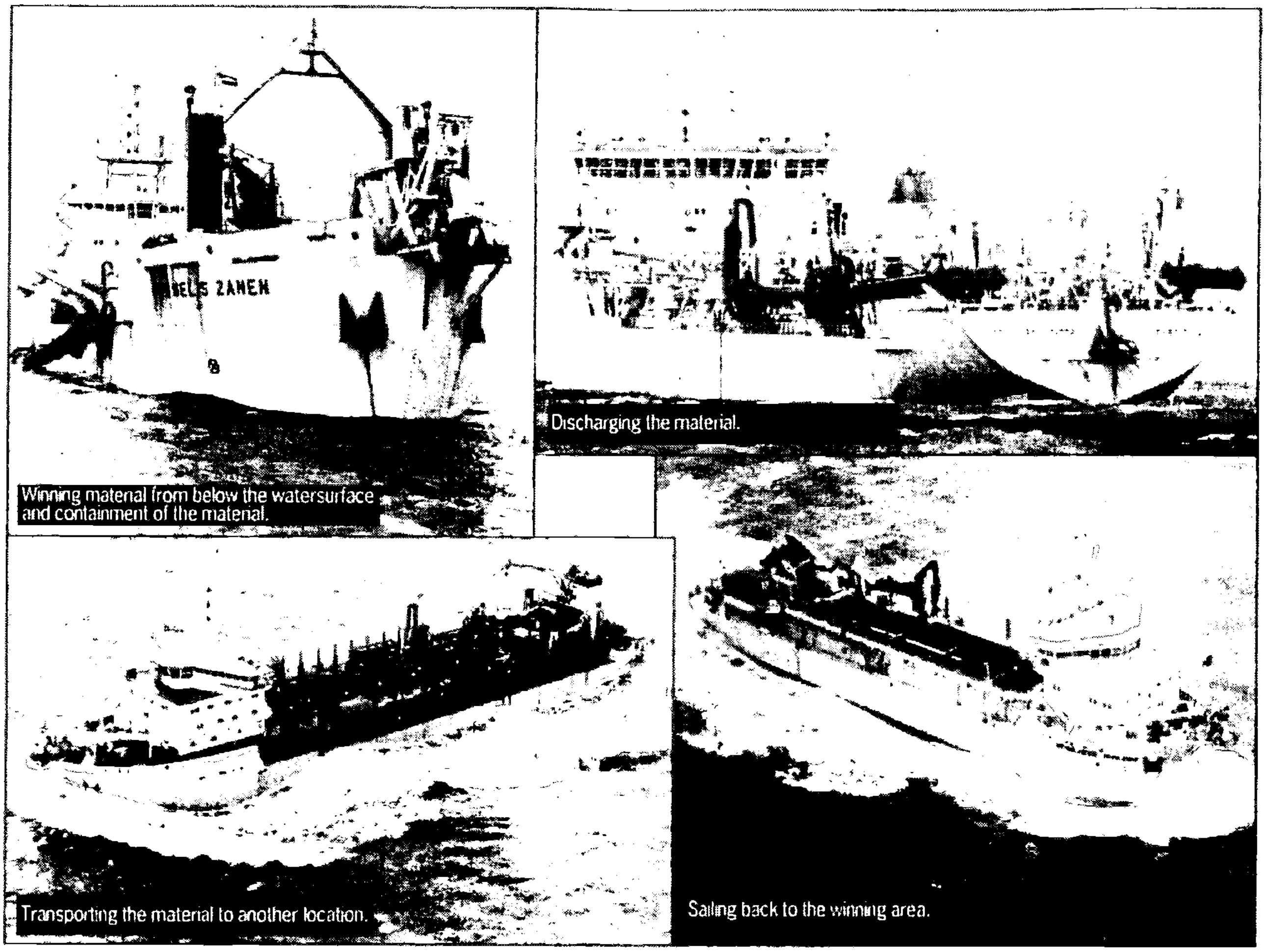


Figure 2. Dredging cycle (with pictures of existing vessels for different parts of the cycle)

Originally the work of the THSDs restricted itself to the so-called depth extension projects. In this work scenario the effort was focused at removal of material from the bottom in order to create a sufficiently deep canal or waterway for the safe passage of shipping. Directly following this came the next type of work typical for the THSDs, the so-called maintenance projects; here the effort was now focused at removal of material from the bottom of waterways in order to prevent depositing blockage due to tidal and or current transport of sedimentation. In both cases the material won has to be deposited (dumped) somewhere before the next dredging cycle can commence.

The winning of material from below the water surface is done by using the principle of a vacuum cleaner. By lowering a suction tube (A), see Figure 1, over the side of the ship by the use of supports/positioning frames called gantries (B), steel connection lines (C) and winches (D) just far enough so that the suction head (E) is just near the bottom. Near enough but not touching. Then a vacuum is created in the suction tube and suction head by the use of a dredging suction pump and the mixture of bottom material and water is sucked up and delivered via pipelines in the ship to the vessels cargo hold called (on board of dredgers) the hopper. During this suction of material on board the vessel is trailing (pulling) the suction tube over the bottom. This costs a lot of power from the vessels propulsion installation.

This above paragraph also explains why this ship type has been awarded the (strange?) name of trailer suction hopper dredger.

Once the hopper is full of material the dredging pump is switched off and the suction tube is retrieved on board (placed in cradles on deck) and the vessel sails off at full speed to the dumping grounds. At the dumping grounds, she deposits the material via the bottom doors or such at slow speed ahead. Then she sails back (at full speed) to the winning grounds and repeats the cycle from the beginning. Such a typical cycle is shown in Figure 2.

The main players

The main players (in the Low Lands) are the following companies in alphabetical order:

Ballast Nedam
Bos Kalis
Dredging International
HAM
J.F.J. de Nul
Van Oord

These companies are well established in the national and international dredging market.

New developments

The above described stereo type trailer suction hopper dredger cycle has been changing recently due to a change in what the client wants. The client wants to do two new things:

- Win material from deeper (and more distant) waters.
- Deposit the newly won material onshore straight from the TSHD (i.e. without the advent of a go between like a static suction dredger unit).

The first wish requires a longer and stronger suction tube and more powerful suction pump installation; implicitly the longer sailing distance requires a larger hopper unit and faster vessel speed in order to guarantee sufficient volumes of material and cycle times. The second requires a suction discharging installation and the possibility of a pressurised delivery ashore of the material taken out of the hopper via the suction discharging facility. In actual fact this shift of effort from depth extension projects and/or maintenance projects to the land reclamation projects has only taken place quite recently. This has been the cause of the evolution of a new breed of TSHDs.

Until recently most hoppers could only dump their cargo. Nowadays there are large harbour projects and these require much land winning. Previously in these cases a method was utilised whereby sand was won by a hopper and dumped before a cutter suction dredger which, in turn, sucked up the sand and transported it via a pressurised pipeline ashore. Needless to say that the dredging companies soon came to grips with the fact that a self suction discharging and shore pressure discharging trailer suction hopper dredger would work more economically on her own.

Land winning became thereby much more important, the projects became yet bigger and bigger (requiring still larger amounts of sand) and on top of this, the sand had to be dredged up via larger sailing distances and greater depths. The economies of scale quickly revealed that big TSHD's can economically carry out this type of work much better than small ones. Through the advent of larger TSHD units, the price that the harbour authorities pay per m^3 sand is so reduced through the economies of scale that still more projects are becoming economically viable.

Data of existing vessels and the new jumbo dredgers

The real 'boom' in size came about with the start of the building of the "Pearl River" ordered by Dredging International. This ship with a hopper capacity of 17000 m^3 was far greater than the "J.F.J.De Nul", which was then the largest TSHD unit with 11750 m^3 hopper capacity.

Not only were big TSHD's built since then but also some smaller ones. From 1990 onwards up to the present day the hopper fleet of the top 6 Dutch-Belgian dredging companies has increased with some 385 000 m^3 hopper capacity.

Figures 3 to 9 show some design data of the vessels shown in Table I. This table is a collection of some of the typical vessels build in this field from 1960 up to the present day taken from the PR fleet data of some of the main players.

Ship name	Hopper Capacity [m^3]	Owner
Pearl River	17000	Dredging International
Gerardus Mercator	18000	Jan De Nul
Amsterdam	18000	Ballast
Fairway	23350	Boskalis
Queen of the Netherlands	23350	Boskalis
Volvox Terranova	20000	Van Oord
Queen of Penta Ocean	20000	Penta Ocean
Nile River	17000	Dredging International
Vasco da Gama	33000	Jan De Nul
Rotterdam	21500	Ballast
HAM 318	23700	HAM
Sestao BN 320	16500	Jan De Nul
Sestao BN 322	16500	Jan De Nul
HAM 318 bis	23700	HAM

Regarding the vessels built since 1990 one can state that the technical concept of all these vessels is still based on that of the "J.F.J.De Nul" which is:

- Dredging installation on the after end of the ship.
- Directly driven dredging pumps.
- Deckhouse on the fore ship.

The Jumbo dredger "Vasco da Gama"

This vessel was delivered recently to J.F.J. de Nul and is the largest TSHD to date.

This vessel also has:

- Dredging installation on the after end of the ship.
- Directly driven dredging pumps.
- Deckhouse on the fore ship.

The following is a more detailed description of this vessel.

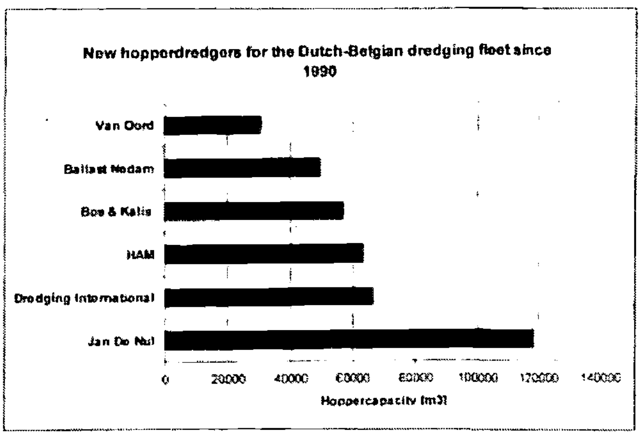
Main propulsion systems and engine room installations

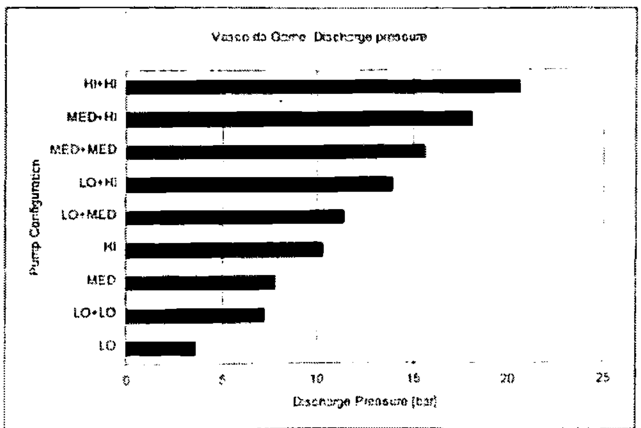
The propulsion installation is typically twin screw with controllable pitch propellers combined with nozzles for high pulling power. In free sailing condition all available power can be absorbed for propulsion purposes. During dredging or shore discharging a large part of the available power can be utilised for the dredging installation.

The sand pump is driven by the main engines via a gearbox.

In the case of shore discharging these dredging pumps have to unload the sand in the hopper (with the aid of water jets in the hopper) and then transport this mixture of sand and water under high pressure through sometimes very long pipelines; this often requires large amounts of power. This is the main reason for the choice of this concept, i.e. the directly driven sand pump. One of the main function of the design of these types of TSHD's, especially the "Vasco da Gama" was shore discharging of the sand. The hopper should be quickly emptied and the sand should be squirted away as far as possible ashore. For this there is only one answer, namely a very large shore discharging pressurised system. The total shore discharge power has evolved from 8800 kW on the "J.F.J.De Nul" to 14000 kW for the "Gerardus Mercator" and finally 16000 kW for the "Vasco da Gama".

Such large power requirements quickly lead to the decision that these pumps should be directly driven: better efficiency, a smaller installation (no separate pump motors etc.), and an improvement in reliability of the complete system as this consists of less critical components. ▶





Of course direct drive of the sand pumps also has a number of consequences. The sand pump gearbox much have a number of different gearbox ratios: when dredging and shore discharging over a small distance the required pressure is small and the sand pump then revolves with a relatively low number of revolutions. In the case of shore discharging over large distances, high pressure is required and the sand pump revolves much higher. Therefore the gearbox has been constructed with a Quill-shaft model and has three gearbox ratio's which can support sand pump revolutions of approx. 165, 230, 260 rpm: by the use of externally mounted gearshift couplings a choice can be made for a given ratio and, at the same time, the sand pump is engaged for use.

When working with two pumps in series, with each pump connected to a gearbox with the possibility of three speeds, the optimum power setting can be chosen via the right choice of gearbox ratio for the type of sand and the discharging distance.

Shaft generators

Besides the dredging pumps there are a number of large electrical users on board. To meet the requirements of these units two large shaft generators, driven through a PTO of the main propulsion gearboxes, have been placed on board.

These shaft generators feed a part of the board net:

- The hydraulic installation: A powerful hydraulic unit, with a power of 2800 kW. The hydraulic power is used for the dredging winches and other auxiliaries.
- The bow thrusters and the stern thrusters. On board of the "Vasco da Gama" there are two 1650 kW bow thrusters and two 750 kW stern thrusters.
- Also these shaft generators are used to supply the underwaterpump installation which is utilised for winning sand at large depths of approx. 130 m.

In order to be able to regulate the revolutions of the sand pump the revolutions of the main engine must also be regulated. This has its consequences:

- The propeller installation has a different rpm, this is no problem as the controllable pitch system is able to adjust for this and tend for the required propeller thrust and see to it that this remains constant.
- The main generators work with variable revolutions and therefore also a variable frequency of 42 to 60 Hz, this means a revolution range of 70 to 100 %. On board of the "Vasco da Gama" both the bow and stern thrusters are fitted with variable pitch

Hopper dredgers

Vessel name	Hopper capacity [m3]	Loa [m]	Breadth [m]	Dredging depth 1 [m]	Dredging depth 2 [m]	Dredging depth 3 [m]	Draught loaded [m]	Draught unloaded [m]	Number of suction pipes [-]	Suction pipe diameter [mm]	Total suction pump power [kW]	Number of propulsion engines [-]	Power per propulsion engine [kW]	Total propulsion power [kW]	Number of propulsion engines [-]	Propulsion power per propulsion engine [kW]	Total propulsion power [kW]	Auxiliary engines [kW]	Total installed diesel power [kW]	Froude Number [v/√(g·Loa)] [-]	Sailing speed [knots]	Complement [persons]	Year of construction [-]	Owner	
Vasco da Gama	33000	200,00	36,20	45,00	60,00	131,00	13,00	6,50	2	1400	9000	2	8000	16000	2	14700	29400	7660	37060	0,19	16,5	40	2000	JFJ de Nul	
HAM 318	23700	170,00	32,00	110,00			13,00		2	1200	11600								28500	0,22	17,3		2001	HAM	
WD Fairway	23347	173,15	32,00	55,00	80,00	120,00	11,49		2	1200	5600	2	5000	10000	2	10000	20000		27550	0,21	16,7		1997	BosKalis	
Rotterdam	21500	180,40	31,00	40,00	60,00	110,00	11,33		2	1200	12000				2	9000	18000		27470	0,19	15,9		2000	Ballast Nedam	
Gerardus Mercator	18000	152,30	29,00	97,00	105,00	112,00	11,51	5,05	2	1200	6000	2	7000	14000	2	9450	18900	2775	21995	0,20	15,2	40	1997	JFJ de Nul	
Amsterdam	18000	156,00	28,00	70,00			10,00		2	1100	10400				2	7000	14000		22000	0,20	15,0		1996	Ballast Nedam	
Newbuilding	16500	150,00	27,80	34,00	48,00		11,10	4,50	2	1100	4800	1	9500	9500	1	8400	8400	1118	17918	0,22	16,5	40	2002	JFJ de Nul	
J.F.J.de Nul	11750	142,85	25,50	30,00	45,00	75,00	9,37	4,75	2	1100	3700	2	4400	8800	2	6195	12390	1790	14180	0,21	15,3	40	1992	JFJ de Nul	
Lelystad	10330	137,00	26,00	55,00	70,00		8,00		2	1200	3700				2	5185	10370		15725	0,21	15,2		1987	Ballast Nedam	
Geopotes 15	9962	133,54	23,64	54,00			9,07		2	1000	3280				2				12445	0,21	15,0		1985	HAM	
HAM 316	9600	128,21	22,00	35,00			9,02		1	1100									11100	0,21	14,2		1998	HAM	
Geopotes X	9075	142,38	22,73	65,00			11,04		2	1200	4414				2				15376	0,19	14,0		1970	HAM	
Alexander von Humboldt	9000	120,50	24,40	31,50	38,00		8,60	4,00	1	1300	3100	1	7500	7500	2	5280	10560	3355	14150	0,22	14,5	31	1996	JFJ de Nul	
Barent Zanen	8000	133,58	23,15	40,70	51,20		8,81	5,00	2	1000	3600	2	2890	5780	2	4560	9120		11438	0,20	14,0		1984	BosKalis	
Cornelis Zanen	8000	132,20	23,00	51,00			8,80		2	1000	3600	2	2950	5900	2	4560	9120		12004	0,20	14,0		1983	BosKalis	
Cristoforo Colombo	7000	115,50	22,20	35,50			8,32	4,50	2	1000	2500	2	3800	7600	2	3990	7980	2870	10850	0,22	14,3	38	1994	JFJ de Nul	
Geopotes 14	6590	127,78	20,63	32,00			8,66		2	1000	3280				2				11330	0,22	15,4		1984	HAM	
Geopotes IX	6400	131,80	21,06	37,00			8,02		2	900	2500				2				8468	0,17	12,0		1967	HAM	
Capitan Nunez	6000	146,50	22,70	21,35			6,90	3,60	2	900	2000	0	0	0	2	3120	6240		10204	0,18	13,5	38	1977	JFJ de Nul	
P.C.S. van Hattem	5600	110,05	18,86	24,00	24,00		8,64		2	900	2206				2				6080	0,26	16,4		1966	HAM	1986
Sandorus	5338	103,00	18,30	25,00			8,20	3,30	2	900	1750	0	0	0	2	2115	4230	740	6780	0,20	12,5	38	1986	JFJ de Nul	
Waterway	4900	97,70	23,00	28,00			6,59	2,93	1	900	1500	1	2760	2760	2			673	6365	0,22	13,2	17	2000	BosKalis	
HAM 309	4600	124,10	19,63	33,40			6,49		2	800									8814	0,21	14,2		1982	HAM	
HAM 317	4400	97,50	19,40	32,00			7,12		1	900	3462				2				6132	0,22	13,0		2000	HAM	
Manzanillo II	4000	113,50	19,00	27,00			8,00	3,20	2	900	4710	0	0	0	2	2355	4710	1989	11410	0,22	14,0	50	1987	JFJ de Nul	
Saga	3910	105,40	16,00	17,00	27,00		5,23		2	700	1620	1	3572	3572	1	4000	4000		5800	0,21	13,0		1985	Ballast Nedam	
James Ensor	3600	112,80	18,20	30,00			6,27	2,85	2	600	1920	2	1620	3240	2	2650	5300	2055	7350	0,20	12,8	41	1980	JFJ de Nul	
Amerigo Vespucci	3500	97,70	17,10	30,00			6,20	3,00	1	900	1240	1	3000	3000	2	2045	4090	1280	5365	0,21	12,5	21	1986	JFJ de Nul	
HAM 312	3500	94,85	17,02	25,00			5,88		1	900	2930								5290	0,19	11,0		1997	HAM	
HAM 311	3500	94,00	17,02	25,00			5,88		1	900									5100	0,19	11,0		1994	HAM	
Nina	3400	89,65	18,40	27,50			5,40	2,80	1	900	1250	0	0	0	2	1325	2650	1311	5551	0,17	9,6	13	1997	JFJ de Nul	
Pinta	3400	89,65	18,40	27,50			5,40	2,80	1	900	1250	0	0	0	2	1325	2650	1311	5551	0,17	9,6	13	1997	JFJ de Nul	
Quality Star	2500	88,00	16,60	20,00					1	800					2				4380	0,23	13,0		1981	HAM	Split hopper dredger
Galilei 2000	2339	83,50	14,50	20,00			4,50	1,85	1	750	720	0	0	0	2	800	1600	435	2975	0,16	9,0	16	1980	JFJ de Nul	
HAM 310	1250	167,60	23,04	35,00	48,00		10,00		2	1100	4420								13810	0,00				HAM	
HAM 350	1128	60,53	11,06	20,00			4,17		1	450	221				1	764	764		1568	0,17	8,0		1975	HAM	Split hopper dredger
Heron	974	65,80	11,20	20,00			3,71		1	450	300								1792	0,18	9,0		1988	HAM	Split hopper dredger

This table is a collection of some of the typical vessels build in this field from 1960 up to the present day taken from the PR fleet data of some of the main players.

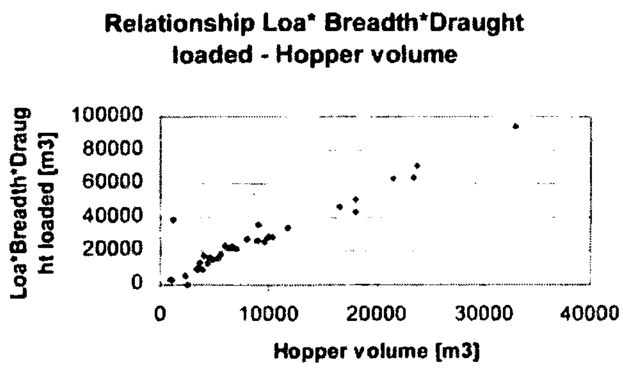


Figure 3. Relationship Loa*Breadth*Draught loaded versus hopper volume

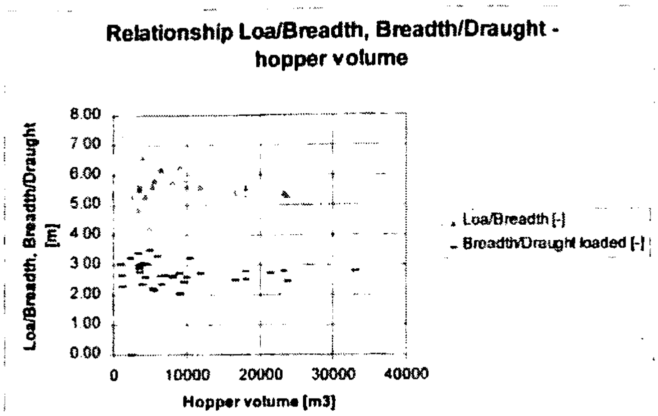


Figure 4. Relationship Loa/Breadth and Breadth /Draught loaded versus hopper volume

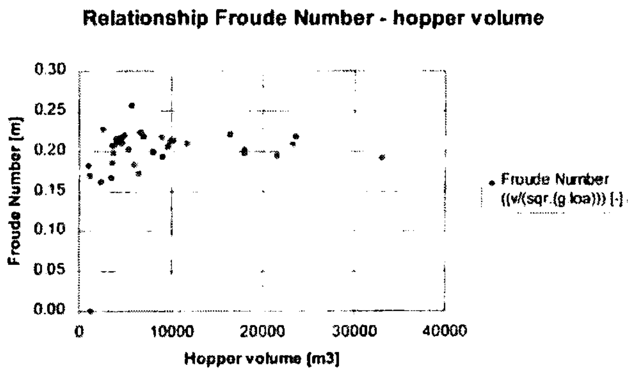


Figure 5. Relationship Froude number versus hopper volume

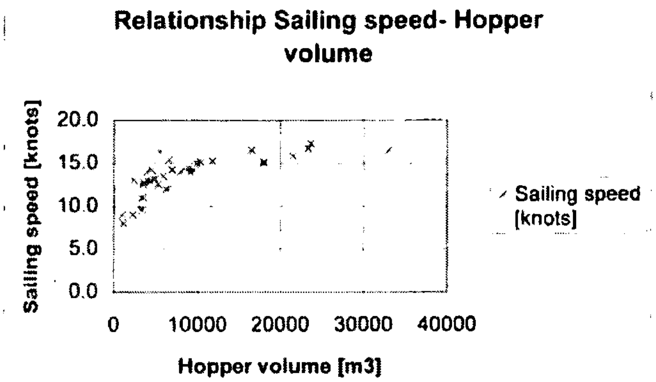


Figure 6. Relationship sailing speed versus hopper volume

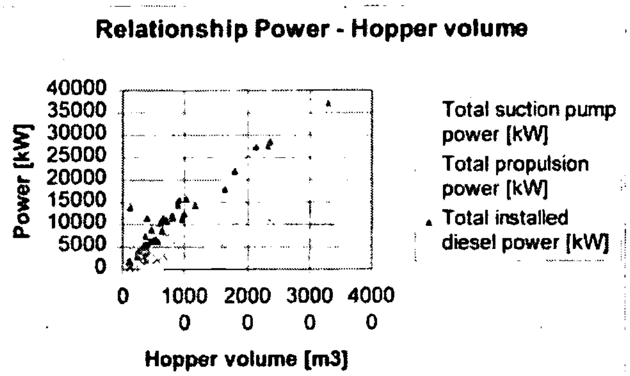


Figure 7. Relationship Power versus hopper volume

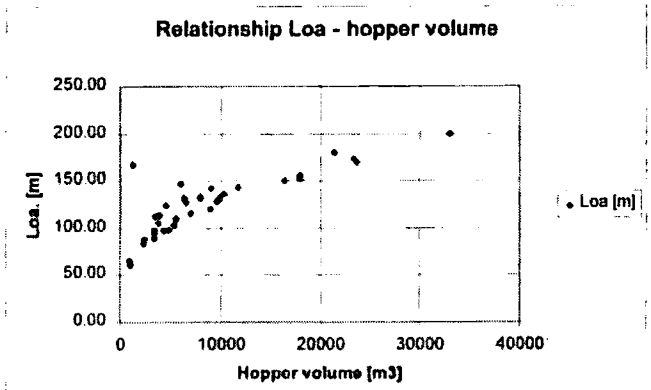


Figure 8. Relationship Loa versus hopper volume

propellers; these are so dimensioned that at 42 Hz, the pitch can be so regulated that they can still be able to absorbed their nominal power, and thereby deliver their nominal thrust.

- The hydraulic pumps, which are also powered by the main generators, are so dimensioned that when revolving at revolutions which comply with 42 Hz they are able to absorb nominal power and deliver nominal volume of sand: This can be simply regulated by the volume rate adjustment of the pumps.

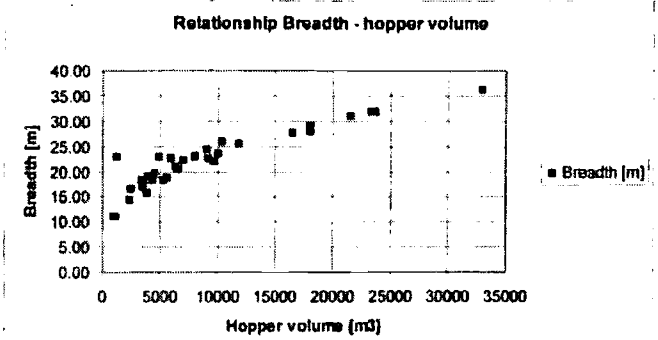


Figure 9. Relationship Breath versus hopper volume

Figure 10. A jumbo dredger at work. "Vasco da Gama" pictured at Singapore, rainbowing.

The Dredging installation:

The 'old' generation large TSHD's ("Humber River", "Prins der Nederlanden", "Geo 10" a.o.), with approx. 10000 m^3 hopper volume, had suction tube with a diameter of 1200 mm. This was the largest size. When the "Pearl River", and afterwards "Gerardus Mercator", were ordered, this traditional large suction tube diameter remained unchanged. Of course due to increasing suction head dimensions and larger pump powers etc. the suction production of these modern ships has increased even though the suction tube diameters have remained the same.

The suction tubes of the "Vasco da Gama" could not remain within this standard size; the suction time would be too long therefore a diameter was chosen of diameter 1400 mm.

Ship size and construction

The hopper volume of 33000 m^3 obviously has been an important factor in determining the dimensions of the vessel. The length between perpendiculars is 178 m, and the overall length is approx. 200 m. Deadweight is around 60000 ton and this led to a breadth of 36.20 m. This breadth means the vessel can not pass through the Panama Canal (Bmax = 32.10 m.)

As a result of the large deadweight and relatively short length the vessel has a dredging draft of 14.60 m. Although large this draft does not present any operational problems for the vessel as one of her main design functions is winning sand from large distances and pumping it ashore for land winning projects..

The large hopper volume and high cargo weight means a heavy loading on the ship's construction. De construction of the "Vasco da Gama" therefore differs in two aspects from the 'classical' jumbo hoppers.

The ship has not got the main deck with hopper side casings (coamings) which rise high above the deck itself. The main deck has been given the same height as the coaming itself. Or stated differently the coaming deck runs over the complete vessel breadth.

The jumbo hoppers built before the VdG were built via the classical concept: two rows of bottom doors with in the middle a 'kippenkooi'. For the extreme size of the "Vasco da Gama" a different concept has been introduced and utilised which looks very like that used by bulkcarriers. The 'kippenkooi' has disappeared and the bottom doors have been placed mid ships.

An implicit advantage of this type of construction is the large freeboard that can be realised.

Hopper subdivision

As much accent is laid on shoredischarging the "Vasco da Gama" has been fitted with a limited number of bottom doors, however with each with a large opening. Despite this the vessel discharges very fast; especially thanks to the fact that the hopper has been fitted with a powerful water jet installation.

The hopper suction discharge installation consists of two channels fitted with suction discharge doors and connected to the dredging pump installation. In order to fluidise the cargo a water jet installation has been fitted which consists of more than 400 (four hundred!) jet sprays.

Automatic control systems

The "Vasco da Gama" is equipped with an integrated control system. The complete dredging installation is integrated and highly automated. A special aspect here is the diagnostic systems; thanks to the input of all data in one system one can easily show the starting and working condition parameters.

On top of this the vessel is equipped with a Dynamic Positioning system that allows accurate and automatically controlled dredging and also is used to keep the ship on course during shore discharging activities.

Accommodation

By JDN a lot of attention is paid to living conditions on board. Everybody knows how difficult it is nowadays to find suitable personnel and a lot is asked as far as performance is concerned from these people. On this vessel the owner has gone very far to make life on board as agreeable as possible. This means a large accommodation space so that each crew member has their own cabin with, of course today's standard, accompanying private sanitary spaces.

Even more has been done to enhance the quality of the accommodations on board. These have been designed with the aid of the owners own interior design architect who has developed his own style which is aimed at producing a peaceful and pleasing environment.

Work

Since the vessel has been delivered she has been working successfully at a land winning project in Singapore (see Figure 10).

References

PR material of the main players Ballast Nedam, Bos Kalis, Dredging International, HAM, J.F.J. de Nul and Van Oord

Material presented on "Vasco da Gama" by Mr. Robbie Bakker (J.F. de Nul) at KNVTS meeting on 26th April 2001 in Rotterdam.