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Manoeuvring characteristics

Sub report 7
Comparison of the Manoeuvring Characteristics of the COSCO 20,000 TEU and other Ultra Large Container Ships

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Abstract

The shipping company COSCO provided data from their new-built 20,000 TEU ultra large container ships (COSCO Shipping Aries) for an evaluation of the accessibility of these ships to the port of Antwerp. Based on a former comparison of the dimensions, telegraph-speed table and manoeuvring behaviour of other container ships in (Eloot et al., 2016) the data of the 20,000 TEU ship is compared with the data of the MSC London, MSC Oscar and CMA CGM Zheng He (and other CMA CGM ships). The comparison shows that the dimensions are almost identical and although the engine power and the harbour full propeller rate are low compared to the other ships, the manoeuvring behaviour based on turning circle, zigzag and crash stop tests is comparable and sometimes in the lower ranges of the considered container ships. Therefore, a trial run on the Western Scheldt can be proposed for the confirmation of the manoeuvring behaviour on the Western Scheldt and no additional simulations must be executed.

“Fields of knowledge: Veiligheid > Maatregelen ter bevordering van de veiligheid > Literatuurgegevens/ervaringsgegevens”

Contents

List of tables

1 Introduction

The shipping company COSCO has asked for an evaluation of the accessibility of the 20,000 TEU ultra large container ship COSCO Shipping Aries to the port of Antwerp. As already many Ultra Large Container Ships are sailing to the Flemish harbours, Flanders Hydraulics Research proposes an evaluation of the manoeuvring behaviour of this new type of container ship based on a comparison of the manoeuvring characteristics of the COSCO Shipping Aries with the characteristics of other ships. A comparable evaluation was published in (Eloot et al., 2016) with a comparison of the MSC London, MSC Oscar and the CMA CGM Zheng He.

2 Ship data

A comparison of the ship data is made through:

- the dimensions and particulars;
- the telegraph-speed table.

2.1 Dimensions and particulars

The Pilot Card, Wheelhouse poster and general arrangement data of the COSCO Shipping Aries are used for the ship data. These different data sources give a little difference in values. As the COSCO Shipping Aries is a single-screw vessel, the ship will be compared with the single-screw vessels of MSC and CMA CGM summarized in (Eloot et al, 2016) and Table 1.

Table 1 – Dimensions and particulars of the MSC London / MSC Oscar / CMA CGM Zheng He / COSCO Shipping Aries

		MSC London	MSC Oscar	CMA CGM Zheng He	COSCO Shipping Aries
Parameter	**Unit**	**Value**	**Value**	**Value**	**Value**
Length over all	[m]	399.0	395.4	399.2	400.0
Length between perpendiculars	[m]	383.0	379.4	381.4	382.0
Beam	[m]	54.0	59.0	54.0	58.6
Draft (design)	[m]	14.5	14.5		14.0
Draft (scantling)	[m]	16.0	16.0	16.0	16.0
Displacement (scantling)	[ton]	242,331.6	258,360.0	240,901.0	255,187
Main engine		Stx Man 11S 90ME-9.2(Nox tier II)	Man B&W 11S90ME-C10.2	Man B&W 11S90ME-C9.2	Man B&W 11S90ME-C10.5-TII
MCR	kW	59,780 at 84 rpm	62,500 at 82.2 rpm	63,910 at 84 rpm	67,100 at 84 rpm[1]
NCR	kW	53,802 at 81.1 rpm	56,250 at 79.4 rpm		
Propeller		Single-screw 6 blades right handed	Single-screw 5 blades right handed	Single-screw 6 blades right handed	Single-screw 6 blades right handed
Propeller diameter	[m]	9.80	10.3	10.0	10.6
Rudder area (movable)	[m²]	95.0	103.6	94.97	
Bow thruster	kW	2 x 1939	2 x 2500	2 x 2000	2 x 2150

[1] In an added document from the shipping company the power and propeller rate for the MCR are 67,100 kW at 84 rpm while the SMCR is lower with 54,950 kW at 72 rpm. (see also https://marine.mandieselturbo.com/applications/projectguides/2stroke/content/printed/S90ME-C10_5.pdf)

The dimensions and particulars of the engine show that the COSCO Shipping Aries has comparable dimensions as the MSC Oscar but due to regulations concerning the Energy Efficiency Design Index and slow speed steaming the engine power of the COSCO Shipping Aries (SMCR) is smaller than this power for the MSC and CMA CGM comparable ships. This reduced power can affect the propulsive behaviour of the vessel although it is expected that the propulsive power can be increased (SMCR to MCR) and is thus comparable to the other container ships.

The rudder area is given. The propeller and bow thrusters power are fully comparable to the other container ships.

In the simulator database the lateral wind area for the MSC London is 16,888 m² for a draft of 13.5 m. The lateral wind area without containers on deck is approximately 8,150 m² for a draft of 13.5 m for the COSCO so that with the a projected area for the containers of 8,000 m² the lateral wind area is the same range as this of the MSC London.

2.2 Telegraph-speed table

For the COSCO Shipping Aries and the other ships the telegraph-speed table is given in Table 2. It is remarkable that the Harbour Full propeller rate is very low up to 37 rpm. In comparison with other ships from COSCO already sailing to Antwerp, the possibility is incorporated to increase the propeller rate after notice in advance (see also Appendix B for the COSCO Denmark).

The shipping company explained that after notice the propeller rate can be increased to:

- 2 mins notice - 47 rpm - +/- 14 knots
- 5 mins notice - 57 rpm - +/- 16 knots

Table 2 – Telegraph-speed table for the loaded or design draft for several ships

	MSC London		CMA CGM Georg Forster		CMA CGM Zheng He		COSCO Shipping Aries	
Draft [m]	14.5		Not given		16.0		Loaded/Ballast	
Engine order	Propeller rate [rpm]	Speed [knots]	Propeller rate [rpm]	Speed [knots]	Propeller rate [rpm]	Speed [knots]	Propeller rate [rpm]	Speed [knots]
Full sea	81.1	24.5	81.1	23.10	84	22.2	72	22.5[2]
Full	70	21.3	67.3	19.3	67	18.3	37	11.9/12.7
Half	56	17.1	50	14.3	56	15.2	30	9.6/10.2
Slow	42	12.9	34	9.75	31	7.0	24	7.6/8.1
Dead slow	34	10.4	22	6.3	20	5.0	18	5.6/6.0
Minimum	16.7	Not given	Not given	Not given	18	Not given		

Although the propeller rates are different for the telegraph positions of the COSCO Shipping Aries compared to the other ships, the propeller rate – speed table of this ship is comparable with the values seen for the CMA CGM Georg Foster. Taking into account the possibilities to increase the propeller rate above the Harbour full value, the propulsive power and the speeds to be obtained are in the same range as for the other container ships.

[2] This speed is for a draft of 14.5 m.

3 Manoeuvring characteristics

3.1 Turning circle test

The results of the turning circle test for the COSCO Shipping Aries are for ballast draft and deep water. For the CMA CGM Georg Forster both results at full loaded condition and normal ballast condition are given but only the normal ballast condition is reported in Table 3. For the MSC London the turning circle results are for a ballast condition and deep water or thus the sea trial characteristics. All manoeuvring data are therefore from a comparable environmental situation, excluding the wind and current effects which should be negligible but seem not to be negligible for the COSCO Shipping Aries.

Table 3 – Turning circle tests

		MSC London		CMA CGM Georg Forster		COSCO Shipping Aries	
		PS	SS	PS	SS	PS	SS
Initial speed	knots	23.0	22.9	23.6	25.7	22.1	20.6
Advance	L_{pp}	3.0	2.9	2.9	3.1	2.4	2.3
Transfer	L_{pp}	-1.4	1.8	-1.4	1.5	-1.7	1.7
Tactical Diameter	L_{pp}	-3.5	4.1	Not given	Not given	-3.0	3.0
Final speed	knots	5.9	7.5	7.9	8.4	4.1	6.3
Time/speed (90 deg)	sec / kts	144 / 13.1	147 / 13.5	122 / 15.2	150 / 14.6	136 / 11.5	148 / 10.8
Time/speed (180 deg)	sec / kts	328 / 7.8	344 / 8.8	280 / 10.7	337 / 8.6	316 / 6.8	314 / 7.4
Time/speed (270 deg)	sec / kts	543 / 6.3	574 / 8.1	488 / 7.9	495 / 8.4	558 / 5.0	519 / 6.5
Time/speed (360 deg)	sec / kts	762 / 5.9	806 / 7.8	Not given	Not given	806 / 4.1	790 / 6.3

During the turning circles executed with the COSCO Shipping Aries the propeller rate was not constant and decreased during the turning circle. Therefore the speed decreased more, especially for the port turn, compared to the turning circles executed with the other container ships. Nevertheless, the non-dimensional advance, transfer and tactical diameter are lower or in the same range (transfer) as for the other ships. The conclusion is thus that the manoeuvrability based on a turning circle test is good for the COSCO Shipping Aries as mainly better than for the other ships and lower than the IMO criteria.

3.2 Zigzag test

In Table 4 and Table 5 the initial characteristics and the first and second overshoot angles are given for the 10/10 and the 20/20 zigzag test results. For the MSC London the first execute was to port while for the SHI type and CSSC type the first course change was to starboard and for the COSCO Shipping Aries both executes are reported. The differences in overshoot angles are negligible so that the initial turning ability and the course changing ability are comparable. The highest overshoot angles are for the COSCO Shipping Aries (4.5 deg for the second overshoot to starboard in the 10/10 zigzag and 8.3 deg for the first execute to port in the 20/20 zigzag) but these values are thus still in line with the other results.

Table 4 – 10/10 zigzag tests

		MSC London	CSSC type[3]	SHI type[4]	COSCO Shipping Aries
		PS	SS	SS	PS / SS
Initial speed	Knots	23.2	N/A	26.1	N/A
RPM (initial/final)	rpm	81.1/75.7	81.1	86.4/72	72 / 72
1st overshoot	deg	3.2	3.0	2.9	3.0 / 2.9
2nd overshoot	deg	3.3	2.5	3.7	3.4 / 4.5

Table 5 – 20/20 zigzag tests

		MSC London	CSSC type[5]	SHI type[6]	COSCO Shipping Aries
		PS	SS	SS	PS / SS
Initial speed	Knots	22.8	N/A	26.1	N/A
RPM (initial/final)	rpm	80.7/67.4	81.1	86.4/71.2	72 / 72
1st overshoot	deg	6.3	5.6	6.2	8.3 / 7.4
2nd overshoot	deg	6.0	4.5	8.2	6.0 / 6.9

[3] These data were for the CMA CGM Vasco de Gama.
[4] These data were or the CMA CGM Kerguelen.
[5] These data were for the CMA CGM Vasco de Gama.
[6] These data were or the CMA CGM Kerguelen.

3.3 Crash stop astern tests

The crash stop astern test results for the COSCO Shipping Aries are for a ballast condition as executed during the sea trial test (Table 6). The crash stop astern test results for the CMA CGM ships are for the full loaded condition in deep water. These test results are estimated results as the full scale trials are not executed in this condition. The results in travel distance for COSCO Shipping Aries are the lowest probably due to the lower initial speed and the ballast condition (astern propeller rate was -55 rpm). The results are almost the same for the MSC London and the CMA CGM Zheng He and largest for the CMA CGM Georg Forster (19.6 L_{PP}) but based on an estimation for the loaded condition while for the normal ballast condition a travel distance of 15.4 L_{PP} was measured during the trial.

Table 6 – Crash stop astern tests

		MSC London	CMA CGM Georg Forster	CMA CGM Zheng He	COSCO Shipping Aries
Initial speed	knots	23.4	Full sea speed	Full (sea) speed	22.8
RPM (initial/final)	rpm	80.9 / -46.8	Ahead to full astern	Ahead to full astern	Ahead to full astern
Travel distance	m / L_{PP}	5569.4 / 14.5	7430.2 / 19.6	5391 / 14.1	4103 / 10.7
Ahead reach	m / L_{PP}	5542.9 / 14.5	Not given	Not given	Not given
Side reach	m / L_{PP}	253.3 / 0.7	Not given	Not given	Not given

4 Conclusions

Comparing the dimensions and manoeuvring characteristics of the COSCO Shipping Aries with these parameters for other single screw ultra large container ships shows that the COSCO has a comparable manoeuvrability.

The largest difference is found in the engine power and the telegraph/propeller rate values. The engine power at SMCR is smaller with 55,000 kW compared 60,000 kW for other ultra large container ships. The MCR power is nevertheless in the same range. As this power is fully used during sea full condition the manoeuvrability in shallow and confined water will not be influenced by this difference.

As the shipping company confirmed that the small full harbour propeller rate of 37 rpm can be increased on 2 to 5 minutes notice in advance, these higher values are necessary to control the ship if engine kicks and thus higher rudder efficiency are helpful.

The characteristics of the turning circle and the zigzag tests of the COSCO Shipping Aries are within the same ranges as the characteristics of the other container ships and fully within the IMO criteria. The travel distance during the crash stop astern test is smallest for the COSCO Shipping Aries.

Based on these conclusions and knowing that the MSC and CMA CGM ships taken as example, already sail along the Western Scheldt to the port of Antwerp, the port will also be accessible for the COSCO Shipping Aries under the same environmental conditions.

5 References

Eloot, K.; Delefortrie, G.; Peeters, P.; Mostaert, F. (2016). Manoeuvring characteristics: Sub report 1 – Comparison of the Manoeuvring Characteristics of the CMA CGM Zheng He and other Ultra Large Container Ships. Version 4.0. FHR Advices, 16_023. Flanders Hydraulics Research: Antwerp, Belgium.

Appendix A:
Lateral wind area without containers on deck

DRAFT EXTREME	LATERAL PROJECTED AREA ABOVE WATER LINE		LATERAL PROJECTED AREA BELOW WATER LINE		LEVER BETWEEN (A) & (S)
	AREA (m2)	KG (m)	AREA (m2)	KG (m)	
	(A)		(S)		(Z)
		①		②	① - ②
0.000	13,340.2	17.76	0.0	0.00	17.76
1.000	12,967.5	18.25	372.7	0.50	17.75
2.000	12,589.2	18.76	751.0	1.01	17.75
3.000	12,207.9	19.27	1,132.3	1.51	17.76
4.000	11,824.5	19.78	1,515.7	2.01	17.76
5.000	11,439.7	20.29	1,900.5	2.52	17.77
6.000	11,054.6	20.81	2,285.6	3.02	17.79
7.000	10,670.6	21.32	2,669.6	3.52	17.80
8.000	10,288.3	21.83	3,051.9	4.02	17.82
9.000	9,906.4	22.35	3,433.8	4.52	17.83
10.000	9,524.6	22.86	3,815.6	5.02	17.85
11.000	9,142.8	23.38	4,197.4	5.51	17.86
12.000	8,760.8	23.90	4,579.5	6.01	17.88
13.000	8,378.2	24.42	4,962.0	6.51	17.90
14.000	7,994.8	24.94	5,345.4	7.02	17.93
15.000	7,610.9	25.47	5,729.3	7.52	17.95
16.000	7,222.3	26.00	6,117.9	8.02	17.98
17.000	6,832.8	26.55	6,507.4	8.53	18.01
18.000	6,442.8	27.09	6,897.4	9.04	18.06
19.000	6,052.1	27.65	7,288.1	9.55	18.10
20.000	5,660.8	28.21	7,679.4	10.05	18.16

NOTES :

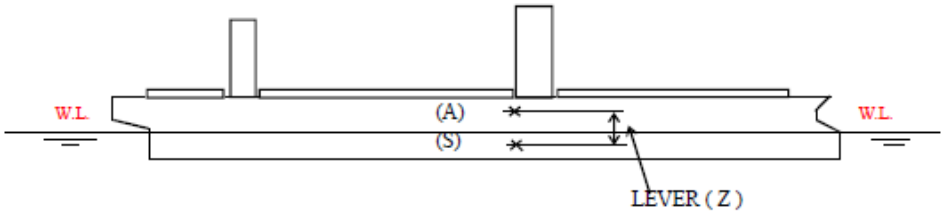
1. LATERAL PROJECTED AREA ABOVE WATER LINE

Hull, F'cle deck, house, funnel, cargo hatch cover, hatch coaming are considered.
Containers on upper deck are not considered.

2. LATERAL PROJECTED AREA BELOW WATER LINE

Hull body (even keel condition) is to be calculated.
Rudder and propeller are not to be included.

3. LEVER BETWEEN (A) & (S)



Appendix B: COSCO Denmark

ENGINE

Type of engine DOOSAN MAN B&W 12K98ME7

Maximum power (MCR): 72240 kW; 90300 HP

Engine order	RPM	Loaded speed (knots)
Max RPM (One turbo charge out of operation) Should be changed based on various Depth/Draft/Displacement	69	18.0
5 Minutes notice advance	63	16.5
2 Minutes notice advance	53	13.9
Full ahead	43	12.1
Half ahead	35	9.8
Slow ahead	28	7.9
Dead slow ahead	20	5.6
Dead slow astern	20	
Slow astern	28	
Half astern	35	
Full astern	43	

Max. No. of consecutive starts: 6

Time limit astern (m): NIL

Engine critical (RPM): **54-62**

Astern power % ahead: Abt 35% ahead

Full ahead to full astern (s): 326 Seconds

Full Sea Speed to Full Astern（Speed 0）: 694 Seconds

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