
 * CALCULATION *
 * OF SHAFTING ALIGNMENT *

SHIP NO. : JR557

SHIP TYPE : 14000DWT PRODUCTS/CHEMICAL TANKER

ENGINE TYPE : YMD-MAN 6S35MC

						6S35MC-SAC
MARK	QUAN.	MODIFI.	SIGN	DATE		
RANK		SIGN		DATE		TOTAL: 10 PAGE: 1
CAL.		钱贵		2008.03.06		DATE 2008-03-06
CHECK		宋宏国		2008.03.06		
J.CHECK						YICHANG MARINE
EXAMINE						DIESEL ENGINE PLANT
VERITY						

I . Engine parameter

1. Type	: YMD-MAN 6S35MC
2. Bore	: 350 mm
3. Stroke	: 1400 mm
4. Max. pressure	: 14.5 Mpa
5. Power (CMCR)	: 4440 kW
6. Speed (CMCR)	: 173 r/min
7. Flying wheel mass	:1845 kg

Prepeller parameter

1.Prepeller diameter	: 4160 mm
2.Number of blades	: 4
3.Pitch ratio	: 0.66
4.Expanded ratio	: 0.55
5.Moment of inertia (in air)	4480kgm ²
6.Mass (in air)	:6280 kg

0 II . Input data

No.	Sect. Dist. (mm)	Outer Dia. (mm)	Concentr. Load (kg)	Correct. Factor	Jack Position	Bearing Length	Remarks
1	0.00	230.0	0.00	1.03	0	0.0	
2	250.0	230.0	0.00	1.03	0	0.0	
3	590.0	319.5	5909.5	1.03	0	0.0	
4	930.0	336.5	0.00	1.03	0	0.0	
5	1393.0	345.0	0.00	0.90	0	730	No.1 Bearing
6	2192.0	345.0	0.00	0.90	0	0	
7	2727.0	336.0	0.00	0.90	0	0	
8	3262.0	336.0	0.00	0.90	0	0	
9	3497.0	340.0	0.00	0.00	0	380	No.2 Bearing
10	4197.0	340.0	0.00	0.00	0	0	
11	4270.0	310.0	0.00	0.00	0	0	
12	4782.0	495.0	0.00	0.00	0	0	
13	4847.0	690.0	0.00	0.00	1	0	Flange
14	4912.0	690.0	0.00	0.00	0	0	
15	5647.0	280.0	0.00	0.00	0	0	TS 1
16	6547.0	280.0	0.00	0.00	1	0	
17	6797.0	280.0	0.00	0.00	0	0	
18	7147.0	300.0	0.00	0.00	0	250	No.3 Bearing
19	7497.0	300.0	0.00	0.00	0		
20	7747.0	280.0	0.00	0.00	1	0	
21	8612.0	280.0	0.00	0.00	0	0	
22	9477.0	280.0	0.00	0.00	0	0	TS 2
23	10197.0	280.0	0.00	0.00	0	0	
24	10277.0	610.0	0.00	0.00	0	0	Flange
25	10332.0	610.0	1845	0.00	1	0	Flying wheel
26	10367.0	750.0	0.00	0.00	0	0	
27	10567.0	390.0	0.00	0.00	0	141	No.4 Bearing
28	10672.0	390.0	0.00	0.00	0		
29	10732.0	475.0	0.00	0.00	0	0	
30	10852.0	866.0	0.00	0.00	0	0	
31	10932.0	475.0	0.00	0.00	0	0	
32	11047.0	390.0	0.00	0.00	0	141	No.5 Bearing
33	11347.0	250.0	2794	7.85	0		
34	11647.0	250.0	0.00	7.85	0	141	No.6 Bearing
35	11947.0	250.0	2794	7.85	0	0	
36	12247.0	250.0	0.00	7.85	0	141	No.7 Bearing
37	12547.0	250.0	2794	7.85	0	0	
38	12847.0	250.0	0.00	7.85	0	141	No.8 Bearing
39	13147.0	250.0	2794	7.85	0	0	
40	13447.0	250.0	0.00	7.85	0	141	No.9 Bearing
41	13747.0	250.0	2794	7.85	0	0	
42	14047.0	250.0	0.00	7.85	0	141	No.10 Bearing
43	14347.0	250.0	2794	7.85	0	0	
44	14647.0	250.0	0.00	7.85	0	141	No.11 Bearing

Shaft weight = 7985.9 kg Sum of external load= 24408.5 kg Total=32394.4 kg

III.Results of straight alignment

Bearing No.	Sect. Dist. (MM)	Out Dia. (mm)	Moment of Bending (kNm)	Stress (N/mm ²)	Reaction (N)	Pressure (KPa)
1	1393	345	50.278	12.47	-95.492	379.16
2	3497	340	1.495	-0.39	5.763	44.61
3	7147	300	9.130	3.44	-24.819	330.91
4	10567	390	7.694	1.34	-45.580	828.87
5	11047	250	1.728	1.13	-5.811	164.84
6	11647	250	2.185	1.42	-28.736	815.19
7	12247	250	2.010	1.31	-26.953	764.62
8	12847	250	2.104	1.37	-27.886	791.10
9	13447	250	1.905	1.24	-25.900	734.75
10	14047	250	2.606	1.70	-32.912	933.68
11	14647	250	0.000	0.00	-9.356	265.42

IV.Bearing reaction influence(in KN per 1 mm rise of bearing)

Bear. No.	1	2	3	4	5	6	7	8	9	10	11
1	17.044	-29.305	16.462	-15.974	12.139	-0.464	0.124	-0.033	0.009	-0.002	0.000
2	-29.305	52.971	-35.349	44.419	-33.755	1.292	-0.346	0.093	-0.025	0.006	-0.001
3	16.462	-35.349	41.051	-111.37	91.978	-3.519	0.943	-0.253	0.067	-0.017	0.003
4	-15.974	44.419	-111.37	1433.9	-2270.6	1165.9	-312.39	83.677	-22.314	5.578	-0.930
5	12.139	-33.755	91.978	-2270.6	4330.1	-2994.5	1096.3	-293.64	78.305	-19.576	3.263
6	-0.464	1.292	-3.519	1165.9	-2994.5	3282.5	-2133.9	865.39	-230.77	57.693	-9.615
7	0.124	-0.346	0.943	-312.39	1096.3	-2133.9	2671.1	-1969.1	817.59	-204.40	34.066
8	-0.033	0.093	-0.253	83.677	-293.64	865.39	-1969.1	2623.3	-1942.7	759.90	-126.65
9	0.009	-0.025	0.067	-22.314	78.305	-230.77	817.59	-1942.7	2565.6	-1738.3	472.53
10	-0.002	0.006	-0.017	5.578	-19.576	57.693	-204.40	759.90	-1738.3	1805.7	-666.58
11	0.000	-0.001	0.003	-0.930	3.263	-9.615	34.066	-126.65	472.53	-666.58	293.91

V. Jack correction factors

Jack No.	Bearing No.	Distance to Bearing(mm)	Correction Factor
1	2	1350	0.884
2	3	-600	0.973
3	3	600	0.888
4	4	-235	1.458

VI. Max. Shear forces, deflections, angle of rotation, and bending stress at each shaft section(Hot condition)

Shaft	Shear force (KN)	B.M (kNm)	Deflection (mm)	Angle of rotation (rad)	Bending stress (N/mm ²)	Permissible bending stress (N/mm ²)
Propeller Shaft	61.417	50.278	0.576	0.442E-3	12.47	20
Inter. Shaft	-10.719	-9.630	1.839	-0.344E-3	-4.47	20
Output Flange of M.E.	5.783	-7.599	1.839	0.381E-5	-0.34	

The twisting angle of Propeller shaft at stern tube supporting is 0.297E-03 RAD .

VII. Optimum alignment results

Bearing No.	Hot condition			Cold condition		
	Offset (mm)	Reaction (kN)	Pressure (N/mm ²)	Offset (mm)	Reaction (kN)	Pressure (N/mm ²)
1	0.0000	-83.468	0.3314	0.0000	-91.495	0.3633
2	0.0000	-15.159	0.1173	0.0000	-10.911	0.0845
3	1.2000	-16.340	0.2179	1.2000	-19.817	0.2642
4	1.8400	-26.643	0.4845	1.9800	-14.672	0.2668
5	1.8400	-24.903	0.7065	1.9800	-35.029	0.9937
6	1.8400	-28.005	0.7945	1.9800	-27.618	0.7835
7	1.8400	-27.149	0.7702	1.9800	-27.253	0.7731
8	1.8400	-27.834	0.7896	1.9800	-27.806	0.7888
9	1.8400	-25.914	0.7352	1.9800	-25.921	0.7354
10	1.8400	-32.908	0.9336	1.9800	-32.907	0.9335
11	1.8400	-9.357	0.2654	1.9800	-9.357	0.2655

VIII. Conclusion

From calculation we have got

1. The specific pressure of all are smaller than the permissible value.
2. The bending stress of all shaft sections is smaller than the permissible value.
3. The twisting angle of Propeller shaft at stern tube supporting is 0.297E-03 rad.
4. Bending moment M= -7.6 kNm, Shear force Q = 5.8+18.1= 23.9 kN at Output flange of main engine. Referring to B&W document: "Maximum allowable loading range at the aft end engine flange", M and F are within the range. See fig.3.

IX. Description

1. The uplift phenomena of the main engine shafting line under hot state has been taken into consideration in this calculation. (uplift $\Delta H=0.14\text{mm}$)
2. The shafting alignment process is carried on after the launching of vessel.
3. Control the gap and sag figures between propeller shaft fore flange and intermediate shaft aft flange at -0.08mm and 0.53mm (tolerance: gap $<\pm 0.05\text{mm}$, sag $<\pm 0.10\text{mm}$).

4. The gap and sag of intermediate fore flange and thrust shaft aft flange are 0.00mm and 0.73mm.
5. After the connection between the propeller shaft and the intermediate shaft, the intermediate shaft is laid on the real bearing instead of temporary bearing with a gap =0.71 mm and sag =-2.41 mm between their connecting flanges. (The negative sign means the center of thrust shaft flange is higher than the intermediate shaft flange. These figures are for reference only during mounting.)

6. Two coefficients are given as below for installation and checking.

- (1). Coefficient of bearing reaction influence

It can be used to forecast the vertical displacement of bearing versus the variation of bearing reaction.

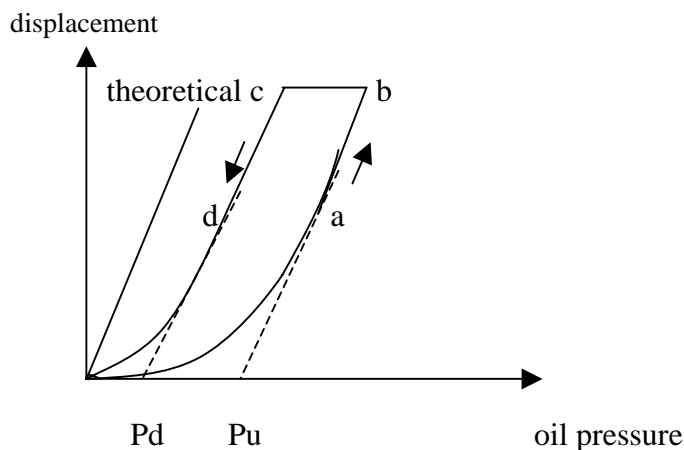
- (2). Uplift coefficient of bearing loads:

Set jacks as per fig. 1. Lift the shaft from the bearing shells by the well-known hydraulic jacks. Multiply the uplift coefficient of bearing loads by the mean value of up-lifting and lowering forces. The products are the bearing loads. In case the jacks arrangement differs from fig.1, the uplift coefficient can be found on fig. 2.

7. If the measuring result yields and error greater than $\pm 20\%$ between the real bearing load and calculating load, an adjustment should be made.

8. The measuring and calculating method for the bearing load:

- (1). Lifting the bearing by hydraulic jack as per the said specified position (may be changed according to concrete condition). Note down the stable oil pressure reading and dial gauge while lifting and lowering. Then make a sketch as follows



- (2). Lengthening the straight line section of the curves, they intersect the oil pressure axis at P_d and P_u . They represent the uplifting oil pressure and lowering oil pressure. Calculate the real load as per following formula: $R_i = C_i \times A \times (P_u + P_d)/2$

P_u – The straight line section of uplift pressure curve ab intersects with horizontal axis.

P_d – The straight line section of lowering pressure curve cd intersects with horizontal axis.

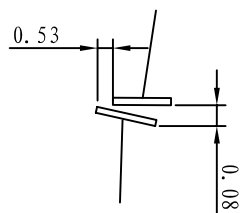
C_i – Uplift coefficient of bearing load.

A – Plunger area of the hydraulic jack.

- (3). In case there is no straight line section on uplifting and lowering pressure curves, make the tangent lines through uplift pointed which should be in paralleled with the theoretical slope. They intersect with horizontal axis at P_u and P_d as shown on the sketch.

9. The cold state mentioned above in this text means that propeller is in part immersed state i.e. in installation state. Propeller concentrated load $= 6280 \times 0.941 = 5909.5 \text{ kg}$.

1#法兰 Gap=-0.08 Sag=0.53



2#法兰 Gap=0.00 Sag=0.73

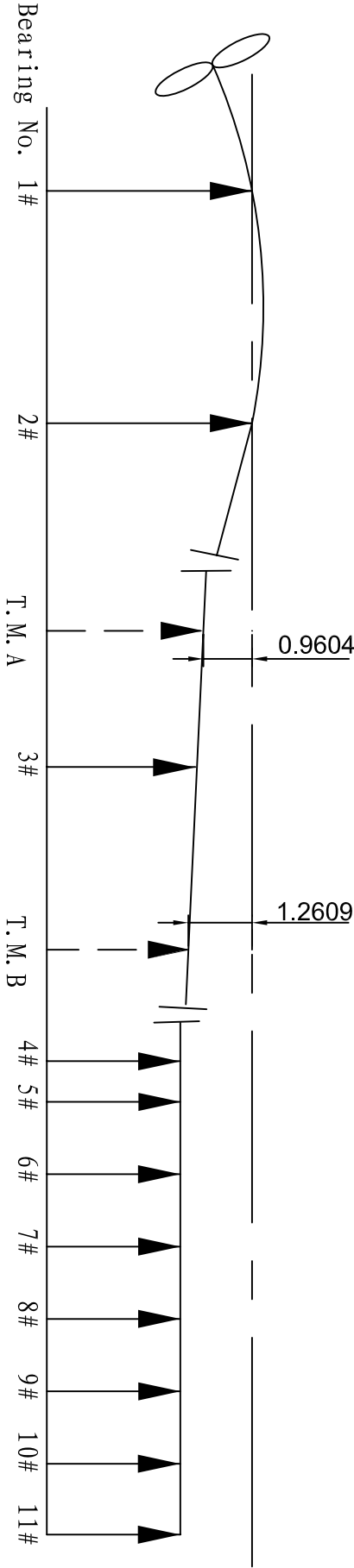
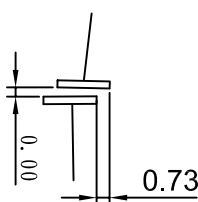


Fig. 2 "Sag" and "Gap" OF SHAFTING ALIGNMENT

Deflectional and Angular rigidity (C) at crank-shaft flange when only $F=100$ kN and $M=100$ kNm is acting at the flange :

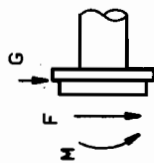
$$C_d F = 0.012 \text{ mm/100kN} \quad C_d F = 0.035 \text{ (mm/m)/100kN}$$

$$C_d M = 0.035 \text{ mm/100kNm} \quad C_d M = 0.155 \text{ (mm/m)/100kNm}$$

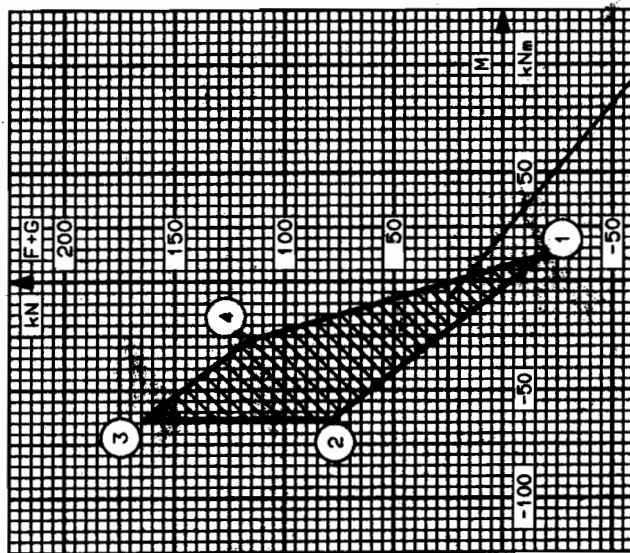
Maximum permissible shear force and bending moment at engine flange (static condition)

Max. permissible bearing reactions (R): max. min.
 1) Aftmost bearing of engine : 137 kN 0%
 2) Aftmost main bearing : 137 kN 5%

Max. permissible bending stress in engine shaft : 15 N/mm²
 Max. permissible bending moment (numerical): 63 kNm



F : shear force (kN)
 M : bending moment (kNm)
 G : weight of turning wheel (kN)



$$M = -7.6 \text{ kNm}$$

$$Q = F + G = 23.9 \text{ kN}$$

	M	F
1	12.2	-19.8
2	-63.4	78.1
3	-63.4	163.8
4	-27.4	117.2

Valid for crank throw no. 243118

Serial Standards (ISO 9001 & Suppl. Drawing No.)		Project No.		Material / Mark.	
0793664-4		01 (01)		Steel / Material	
Date		Chg. No.		Chg. / Revision	
20030725		01		01	
Station Drawing No.		4-12S35MC		MAN B&W Diesel A/S	
384620		Static thrust shaft load		0794949-1	
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