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Introduction

Engine specific equivalent two-dimensional crankshaft models are provided just for those alignment layout calculations (ALC), which are created with other programs than Wärtsilä's EnDyn calculation program[1].
These crankshaft models provide similar static load results only for the aft three engine main bearings (mb #1 to mb #3) as calculated with the EnDyn integrated three-dimensional finite element (FE) crankshaft models[2] when the aftmost crank (cylinder #1) is in top dead centre (i.e. at crank angle zero degree position).
This turning position of the crankshaft is considered as the reference condition.

Abbreviations

The following abbreviations are used in this document:

ALC	alignment layout calculation
DG	design group (Wärtsilä drawing set structure)
FE	finite element
mb	engine main bearing
mb #(n)	foremost engine main bearing
TVC	torsional vibration calculation

[1] Wärtsilä's EnDyn calculation program is provided on order and free of charge to Wärtsilä's licensees and shipyards installing a Wärtsilä engine (see DG9709 - "Engine alignment – Introduction" - section "Wärtsilä alignment services").

[2] The ALC results provided with the EnDyn integrated three-dimensional crankshaft calculation models are very realistic and thus are considered as reference.

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Modif	Number	Drawn Date		Number	Drawn Date		Number	Drawn Date		Number	Drawn Date			

WÄRTSILÄ	Product: W-2S		**Engine Alignment** **Equivalent two - dimensional crankshaft model**
Made	14.10.2013	J.Bergande	Main Drw.
Chkd	18.10.2013	W. Schiffer	Design Group: 9709
Appd	21.10.2013	B.Haag	

Page: 1 / 5	Material ID: PAAD128844	
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1 Equivalent two-dimensional crankshaft models

The equivalent two-dimensional[3] crankshaft model consists of the following elements:

- Main coupling flange and thrust shaft.
- Cylinders of similar stiffness in the range of the aft three cranks.
- Forces to simulate the masses of cranks, running gears, thrust collar and gear wheel[4] [5].
- Elastic main bearings with clearance.

The relevant engine specific data for the equivalent crankshaft model, as illustrated in figure 1, is provided by table 1.

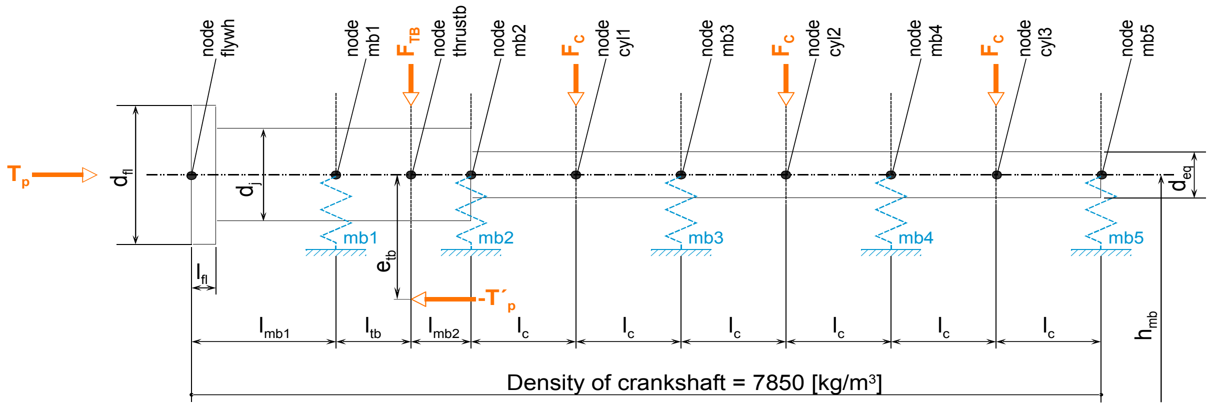

Figure 1: equivalent two-dimensional crankshaft model.

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3 The calculation model elements are composed just on two axes: horizontal (lengths) and vertical (diameters).

4 Most engines have the gear wheel arranged aft of the cylinders. Just the large bore engines with higher number of cylinders have the gear wheel arranged between the cylinders and thus have a lower mass at the thrust collar, i.e. lower "F_{TB}" values (see table 1).

5 The sum of all static bearing loads in one crank angle position, e.g. crank angle 0°degree, refers directly to the masses carried by the bearings.
However, the sum of all measured static (main) bearing loads does not directly refer to the related masses, as it is common use to perform jack-up tests at different crank angles (see DG9709 - "Engine alignment – Guidelines for measurements").

Table 1	Equivalent two-dimensional crankshaft model data for Wärtsilä 2-stroke engines													
Designation	l_{fl}	d_{fl}	l_{mb1}	d_j	l_{tb}	l_{mb2}	d_{eq}	l_C	F_{TB}	F_C	h_{mb}	e_{tb}*1	Bearing stiffness*2	Bearing clearance
Engine Type	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[N]	[N]	[mm]	[mm]	[N/m]	[mm]
W5-8X35	100	695	328	430	277	155	220	306	7926	34192	830	-183	4.0E+09	0.3
W5-8X40	115	816	370	490	325	175	255	350	9359	46454	980	-210	4.0E+09	0.3
W4-8X62	180	1235	564	760	501	356.5	420	553	34590	178415	1360	-322	6.0E+09	0.5
W4-8X72	210	1395	697	880	504	386	470	646	47834	280036	1575	-370	6.0E+09	0.5
W6-9X82	220	1458	810	1020	587.5	350	565	752.5	62509	422890	1800	-317	8.0E+09	0.7
W-X92	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5-8 RTA48T-B/T-D 5-8 RT-flex48T-D	125	913	451	585	307.5	196.5	309	417	14960	76390	1085	-188	3.0E+09	0.4
5-6 RTA/RT-flex50/-B/-D 5-6 RT-flex50DF	120	970	436	600	365	211	328	440	16986	96200	1088	-282	4.5E+09	0.4
7-8 RTA/RT-flex50/-B-/D 7-8 RT-flex50DF												-215		
5-8 RTA58T-D 5-8 RT-flex58T-D/-E	150	1108	520	706	367.5	237.5	375	503	25418	138341	1300	-228	3.5E+09	0.5
5-8 RTA/RT-flex60C-B	160	1118	550	730	412	235	404	520	30411	146856	1300	-250	5.0E+09	0.5
5-8 RTA68-D 5-8 RT-flex68-D	175	1298	622	828	448	270	441	590	24535	213740	1520	-276	4.0E+09	0.6
6-8 RTA/RT-flex82C	220	1458	810	980	587.5	350	575	752.5	62509	356710	1607	-342	6.0E+09	0.7
9-12 RTA/RT-flex82C									47700					
6-9RT-flex82T/T-B 6-8RTA82T/T-B	220	1458	810	1020	587.5	350	565	752.5	62509	422890	1800	-317	8.0E+09	0.7
9RTA82T/T-B	220	1458	810	1020	587.5	350	565	752.5	47700	421610	1800	-317	8.0E+09	0.7
5-7 RTA/RT-flex84T-D	220	1458	870	980	635	365	552	750	59282	350894	1800	-299	6.0E+09	0.7
8-9 RTA/RT-flex84T-D									37818			-317		
6-7 RTA/RT-flex96C-B	210	1458	870	990	615	295	620	840	68503	434348	1800	-314	5.0E+09	0.7
8-12 RTA96C-B 8-14 RT-flex96C-B									43743			-342		

*1 The minus sign indicates that the propeller thrust reaction force acts below the crankshaft centre line.
70% of the thrust bearing eccentricity "e_{tb}" is effective for the vertical downward offset of the propeller thrust reaction force when forwarding the vessel. Thus a bending moment is formed at the forward side of thrust collar by the axial propeller thrust acting in the centre of the shaft and the propeller thrust reaction force with its vertical downward offset "e_{tb}". This bending moment lifts the crankshaft aft end flange when forwarding the vessel.

*2 The static bearing stiffness has to be considered correctly.

1.1 Application of the equivalent two-dimensional crankshaft model

It is mandatory to use the full equivalent two-dimensional crankshaft model as illustrated in figure 1 in combination with the engine specific data provided by table 1; **otherwise the calculation results are not valid!**

The model includes the aftmost mb #1 up to mb #5 as well as their elastic supports. The **elasticity of the main bearing supports refers to stopped conditions** – i.e. no oil film is considered. This corresponds to the actual condition during the measurements of static bearing loads (so called 'jack-up tests').

Alignment calculations which do not consider the correct elasticity of engine main bearing supports are wrong and consequently cannot be judged with the Wärtsilä limits and recommendations.

All elements of the equivalent two-dimensional crankshaft model **have the density of 7850kg/m³ for steel** as shown on the bottom of the illustration.

The case specific mass of the flywheel[6] has to be added at the aft end of the equivalent two-dimensional crankshaft model.

Alignment calculations based on equivalent two-dimensional crankshaft models provide similar static load results for the aft three engine main bearings (mb #1 to mb #3) as calculated with the EnDyn integrated three-dimensional FE crankshaft models when the aftmost crankpin (cylinder #1) is in top dead centre (i.e. at crank angle zero degree position). However, the following deviations can be expected between ALC results which consider the two-dimensional crankshaft models and those which consider the EnDyn integrated three-dimensional FE crankshaft models:

- about 5% for mb #1 and mb #2
- about 10% for mb #3 – in some special cases even more.

The static loads calculated for mb #4 and mb #5 are not to be regarded. The consideration of these bearings is just necessary to get proper results for mb #1 to mb #3 within the above mentioned accuracy.

Due to the explanations provided in section 1.2, it also would make no sense to enhance the two-dimensional crankshaft model in order to calculate static loads of additional main bearings, i.e. mb #4 to foremost mb #(n).

1.2 Restrictions of the equivalent two-dimensional crankshaft model

Real cranks have a three-dimensional geometry and thus an uneven lateral bending stiffness. This causes varying static main bearing loads when the crankshaft is turned, i.e. the static main bearing loads also depend on the crank angle (see DG9709 - "Engine alignment – Guidelines for measurements" - section "Influence of crank angle on main bearing load").

In contrast, equivalent two-dimensional crankshaft models have constant lateral bending stiffness also in way of the cranks since they consist just of cylinders. Thus **equivalent**

6 The flywheel size is determined by the case specific torsional vibration calculation (TVC).

two-dimensional crankshaft models cannot simulate the varying static main bearing loads at different crank angles.
Consequently alignment calculations which consider two-dimensional crankshaft models cannot provide the following information:

- The static loads of mb #2 to foremost mb #(n) when the crank next to relevant main bearing is in horizontal exhaust side position[7] as per common use during the measurement of static loads for these main bearings.
- Pre-calculation of the curves of plotted jack-up test results.

[7] For practical reasons, it is common use to turn the crank next to relevant main bearing into horizontal exhaust side when performing jack-up tests of mb #2 to foremost mb #(n) (see DG9709 - "Engine alignment – Guidelines for measurements").
In contrast, jack-up tests for shaft bearings and aftmost mb #1 are performed when the aftmost crankpin (cylinder #1) is in top dead centre (i.e. at crank angle (CA) 0 degree position).

WinGD-2S – Alignment_equivalent 2-D crankshaft model

TRACK CHANGES

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