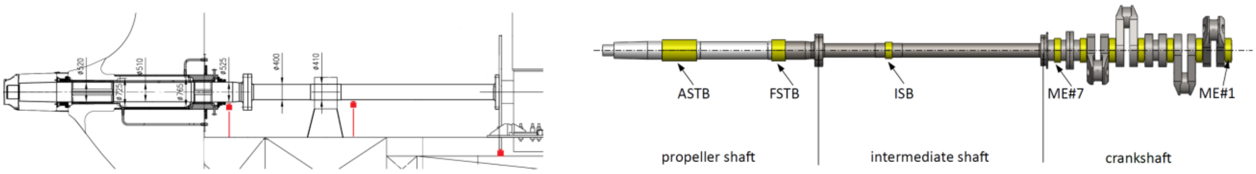
Investigation of the static reactions of a ship's shaft line with consideration of radial runout

Ch. Pirovsky

This article deals with the study of static reactions in the support bearings of the ship's shaft line, taking into account the influence of radial runout caused by residual deformations of the shafts.

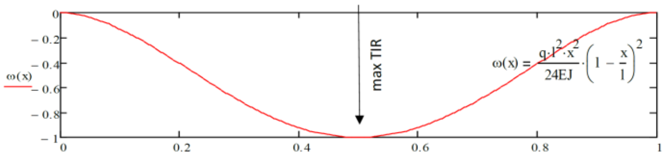
The main goal is to establish how geometric deviations occurring during operation or after repair activities affect the distribution of reactions on the supports and the stressed state of the shaft line.

For the purposes of the study, a numerical model of the shaft line was developed using the finite element method:

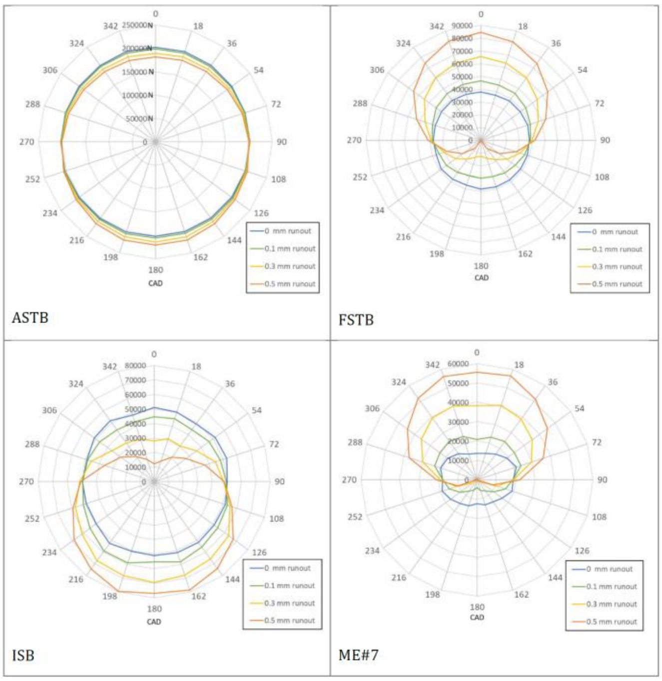


Parametric calculations were performed at different values of radial runout, and the resulting changes in loads and deformations were analyzed.

The residual deformation is given as a smoothly varying radial deflection along the length of the intermediate shaft with a maximum value in the mid-section of the intermediate shaft. To conduct the study, the maximum total indicator runout (TIR) was set in the middle section of the intermediate shaft for 4 cases, as follows: 0 mm (no deformation), 0.1 mm, 0.3 mm and 0.5 mm.

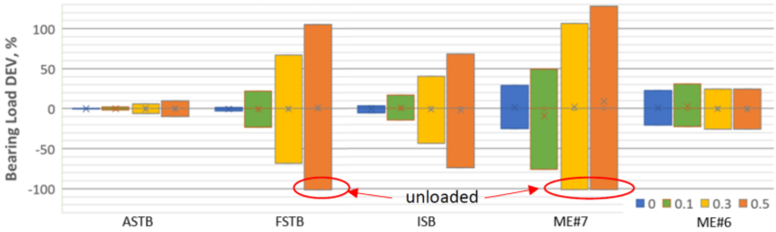


As a result of the numerical FEM study, polar diagrams of the calculated static reactions (N) were obtained for each bearing on the shaft line in accordance with the angle of rotation of the crankshaft:



The analysis of the results of the numerical calculations performed shows the following maximum deviations in the bearing load depending on the magnitude of the residual deformation:

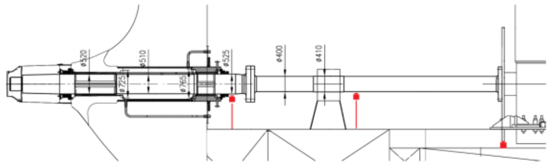
	Max. Bearing Load Deviation, %				
TIR, mm	ASTB	FSTB	ISB	ME#7	ME#6
0	+0.6	+1.8	+3.7	+29.0	+22.7
	-0.4	-3.2	-5.2	-25.0	-20.8
0.1	+2.1	+21.9	+16.7	+49.0	+30.6
	-1.8	-23.5	-14.2	-76.0	-22.3
0.3	+6.3	+66.8	+40.5	+106.6	+24.3
	-5.9	-68.1	-43.5	-100	-25.6
0.5	+10.0	+105.0	+68.2	+128.1	+24.5
	-9.8	-100	-74.0	-100	-26.0



Experimental verification

An experimental verification of the reactions of the shaft line of a real 35900 TDW ship, identical to the model in the numerical study, was carried out. The reactions were measured using the Jack-up method for three bearings, in 4 positions through a 90° rotation of the crankshaft:

Bearing Load Deviation, %			
BRG	FSTB	ISB	ME#7
Max.	+13%	+90%	+83%
Min.	-13%	-87%	-71%



Conclusion

The numerical study using a three-dimensional FEM model shows that the residual deformations of ship shafts have a significant impact on the static reactions of the bearings. Even small deviations (Runout 0.1mm) lead to a significant redistribution of loads, especially in the FSTB, ISB and ME#7 bearings, and at larger deformations the changes reach over 100%.

Comparison with measurements from a real ship confirms that the observed large variations in the reactions are due to residual deformations, which makes it impossible to directly compare the measured values with the manufacturer's design data.

The results obtained emphasize the need to control the geometric deviations in the shaft lines, especially when assessing the operational loads of the bearings and preventing vibrations, accelerated wear and damage from alternating cyclic loads.