Universität Rostock Traditio et Innovatio

Measurement method for dynamic shaft bearing loads resulting from axial vibrations in a propulsion shaft system of a megayacht

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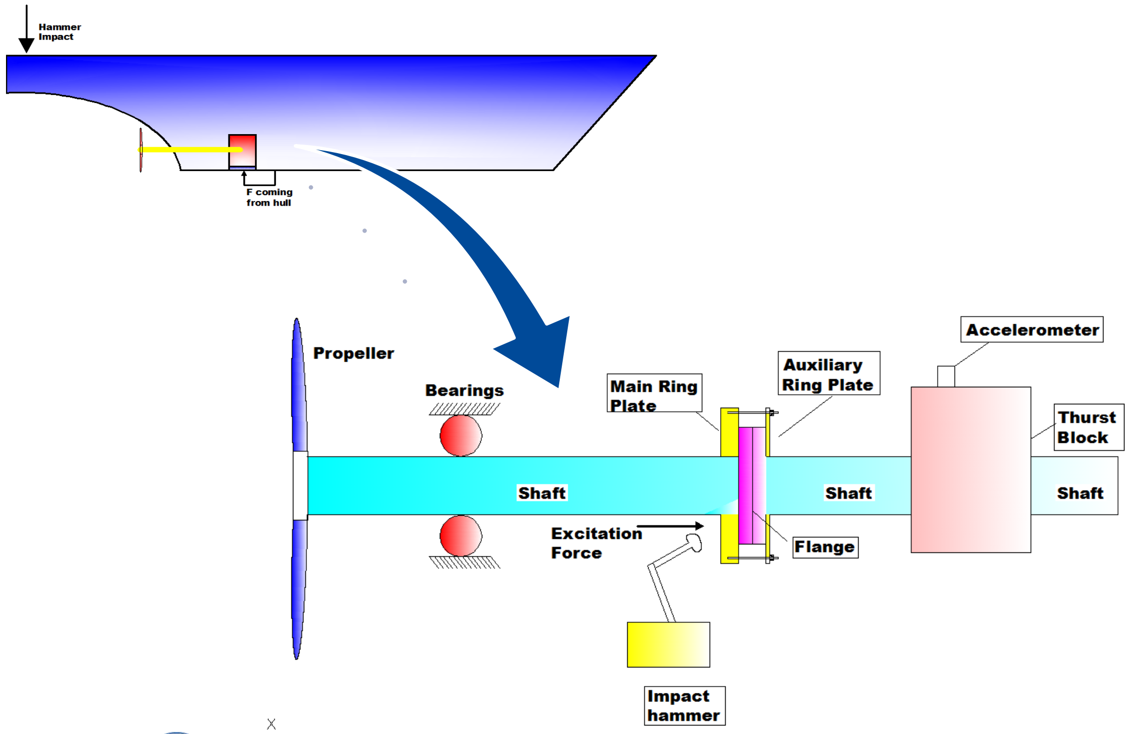
1- Motivation of the master thesis

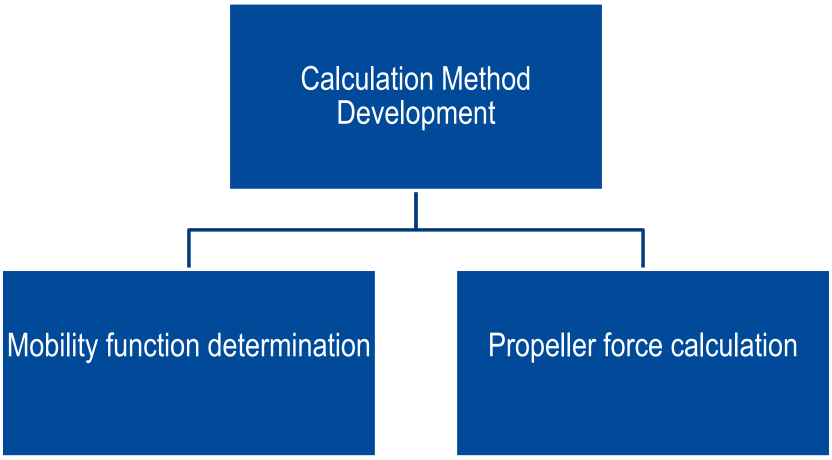
- Axial shaft vibration is an important problem for mega yachts in terms of comfort.
- To find a measurement method for shaft axial vibration.
  - On a navigating real ship
- To compare the calculated and predicted vibrations with the experimental one.

2-Axial Vibration Measurement



x

Calculation Method Development



Mobility function determination

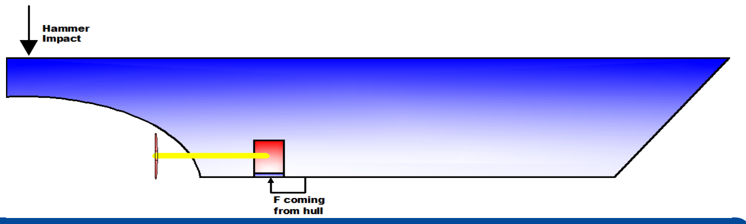
- ❑ The mobility function

Mss=v/F

- ❑ The response of the shaft can be expressed

v=v1+v2+v3

- ❑ Shaft response due to ship hull itself (v1)
- ❑ Shaft response due to propeller (v2)
- ❑ Shaft response due to excitation (v3)



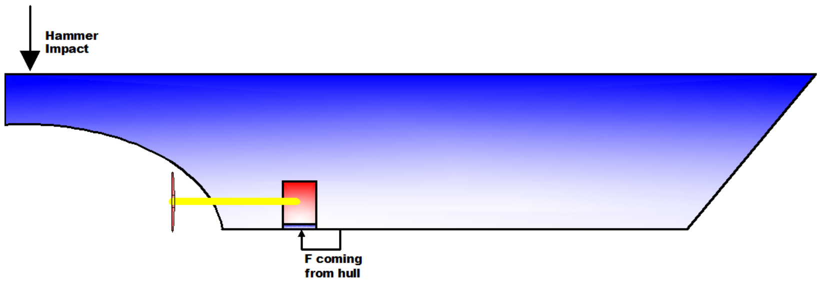
Steps to find the mobility function of the shaft

Step 1

- ❑ Impact to the hull to obtain the mobility function of the hull. V=0 (velocity)

v_2^i =0 (no vibration from the propeller, V=0, moored)
v_3^i =0 (no impact to the shaft)

$$v^i = v_1^i \qquad v_1^i = F_1^i * M_{hull}$$



Step 2

- ❑ Normal working of ship (no impact)
- ❑ V≠0 (velocity)
- ❑ Response is the sum of propeller and the hull response.

v_3^{ii} =0 (no impact to the shaft)

- ❑ Hence, the response will be

$$v^{ii} = v_1^{ii} + v_2^{ii}$$

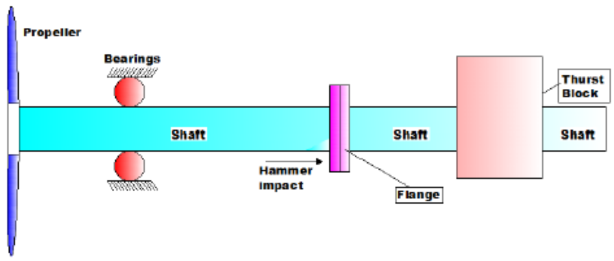
Step 3

(same speed with step 2) V≠0

- ❑ Impact to the shaft to obtain the mobility function of shaft and propeller system.

$$v^{iii} = v_1^{iii} + v_2^{iii} + v_3^{iii}$$

- ❑ $v_1^{iii} + v_2^{iii}$ is already known ($v_1^{ii} = v_1^{iii}$ and $v_2^{ii} = v_2^{iii}$) => same condition with step 2
- ❑ The difference between operation 2 and 3 is the impact force.



Step 3

(same speed with step 2) V≠0

- v_3^{iii} = $v^{iii} -- v_1^{iii} - v_2^{iii}$
- Response of the shaft due to excitation(v_3^{iii}) is found.
- Mobility function of the shaft (Mss)

$$Mss = \frac{v_3^{iii}}{F_{impact}}$$

Calculation of force coming from propeller

In operation step 2, v^{ii} is measured.

$$v^{ii} = v_1^{ii} + v_2^{ii} \quad (1)$$

v_1^{ii} = response of the hull in operation 2

v_2^{ii} = response due to propeller in operation 2

Equation 1 can be expressed in other way in terms of force and mobility function (v^{ii}, M_{hull} and M_{ss} are already known)

$$v^{ii} = F_1^{ii} * M_{hull} + F_2^{ii} * M_{ss} \quad (2)$$

F_1^{ii} = force coming from the hull during operation 2

F_2^{ii} = force coming from the propeller during operation 2

Response due to propeller can be defined in terms of velocity and mobility function (M_{ss} is known)

$$v_2^{ii} = F_2^{ii} * M_{ss} \quad (3)$$

In operation 2, the response of the hull in terms of velocity and mobility function is

$$v_1^{ii} = F_1^{ii} * M_{hull} \quad (4)$$

Force calculation iterations

Guessing F_1^{ii}

Putting F_1^{ii} in Eq. 2 and finding F_2^{ii}

$$v^{ii} = F_1^{ii} * M_{hull} + F_2^{ii} * M_{ss}$$

Putting F_2^{ii} in Eq. 3 and finding v_2^{ii}

$$v_2^{ii} = F_2^{ii} * M_{ss}$$

Putting v_2^{ii} in Eq. 1 and finding v_1^{ii}

$$v^{ii} = v_1^{ii} + v_2^{ii}$$

Putting v_1^{ii} in Eq. 4 and finding F_1^{ii}

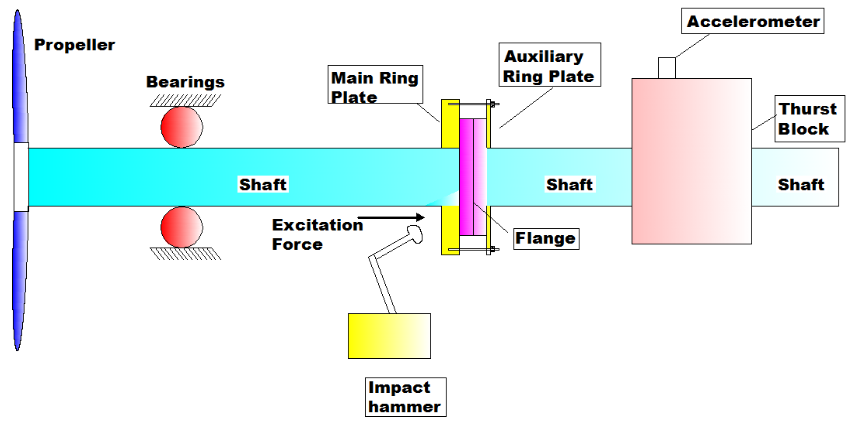
$$v_1^{ii} = F_1^{ii} * M_{hull}$$

Comparing F_1^{ii} found in previous step with initial one.

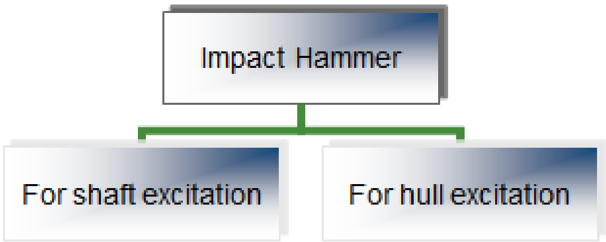
F_1^{ii}

Measurement Experiment Design

- ❑ Impact hammers
- ❑ Accelerometers
- ❑ Remote control units
- ❑ Steel plates



Impact Hammer Selection

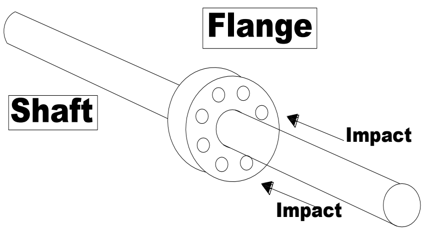


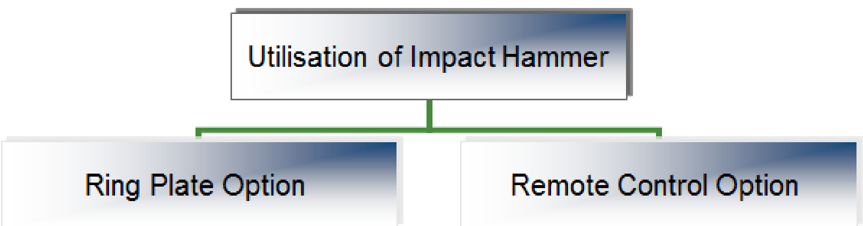
- ❑ Electric Impact Hammer for Shaft

Force Range (N)	Sensitivity (mV/N)	Weight (kg)	Overall Dimensions (LxWxH) cm
220 -2200	1,1	7,7	40,5 x 18 x 11,5

Utilisation of impact hammer

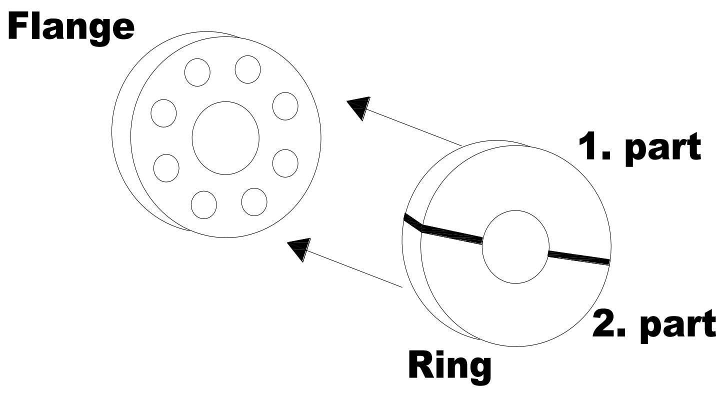
Hitting the shaft in x direction





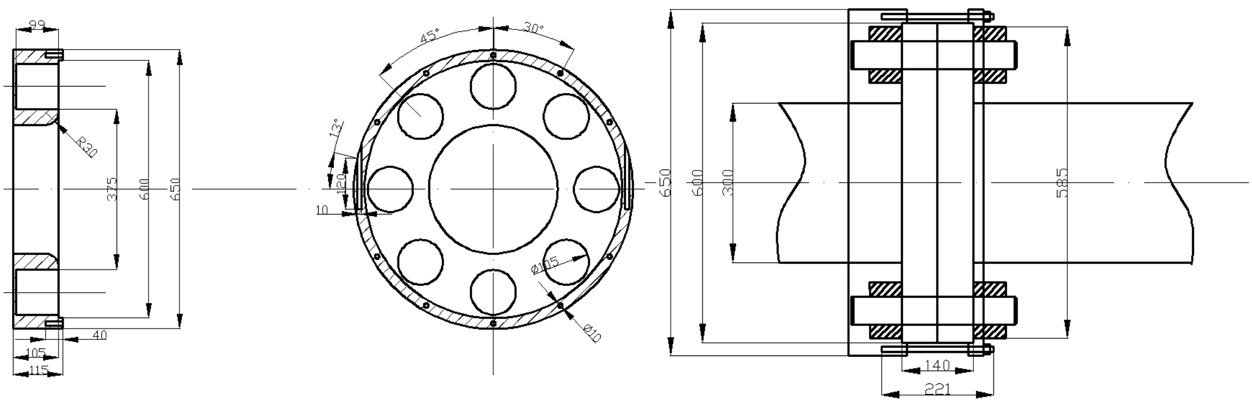
Ring Plate Option

- ❑ Two parts ring to obtain flat surface



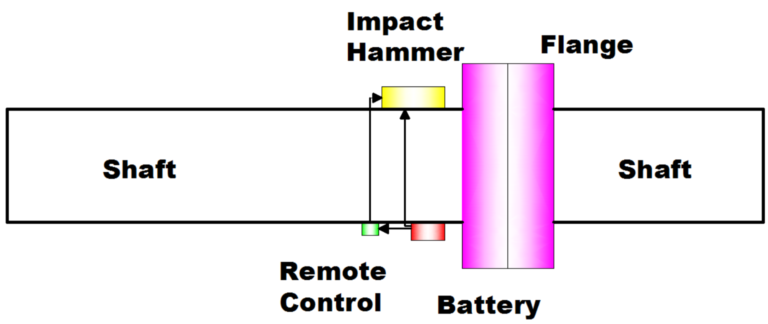
Ring Plate Option

Additional plate to fix the main plate in x direction



Remote Control Option

- ❑ Attaching the impact hammer on the shaft
- ❑ Remote control momentary switch
- ❑ Li-Po battery



Accelerometer Selection

- ➢ Acceleration due to propeller

a=3 m/s2

20 tones axial load coming from propeller

- ➢ Acceleration due to impact hammer

a=0,03 m/s2

2000 N impact force

Conclusion

- A new force calculation method based on mobility function was developed.
- Experiment set-up was designed.
- Material and the device selection for the experiment was performed.

QUESTIONS