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Modeling and simulation of a flexible damper during ice in propeller impacts

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Introduction

Shipping in ice waters leads to many stresses on vessels. One area of interest in this case is the effect of propeller- ice impacts on the vessels' propulsion train. The impact of the propeller blades on ice leads to vibration peaks in the shaft which can transmit to the bearings and the engine. To avoid damage to the engine, flexible couplings are used to stop the transmission of vibrations through the shaft. However, these coupling are usually designed for regular smaller vibrations and there is not much knowledge about the behavior of flexible couplings during irregular peak loads caused by the ice impact. Therefore a flexible coupling is modeled with the Bond-Graph-Method and simulated in 20-sim. Then it is inserted in a drive train model and subjected to engine vibrations and ice impact peak loads.

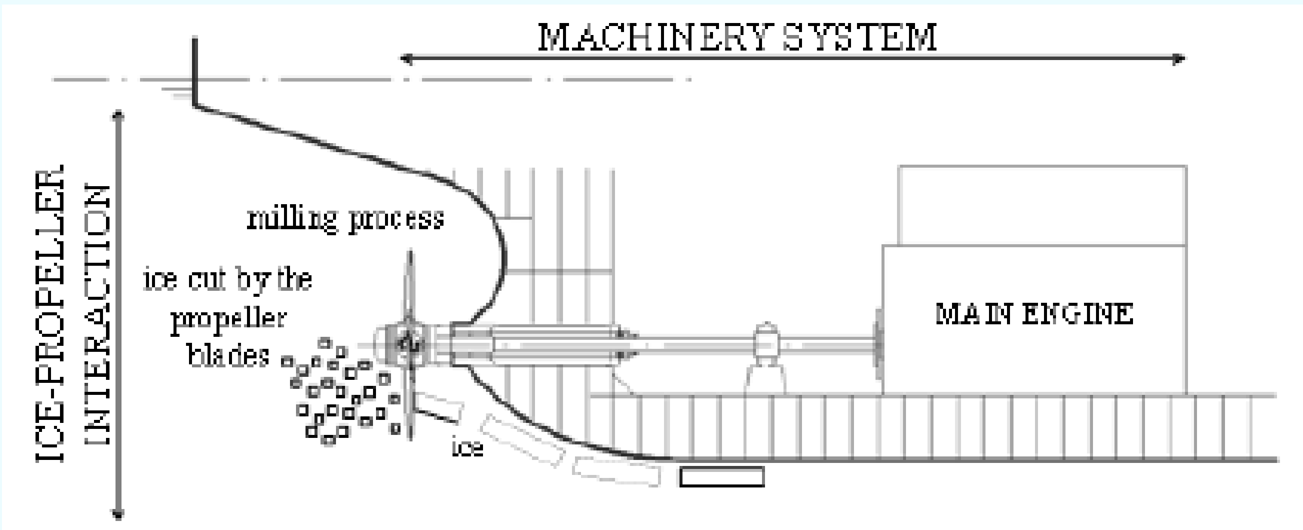

Figure 1: Propulsion train during ice impact

Coupling

The coupling used in this thesis is a steel spring, oil damped type from Geislinger GmbH. It can turn equally in both directions.

The driving wheel of this coupling is the outer wheel. It is connected to the driven inner wheel by a number of flat springs that transmit the power. The springs are fixed to the outer wheel and reach into grooves within the inner wheel. The twist is limited in both by a bumper.

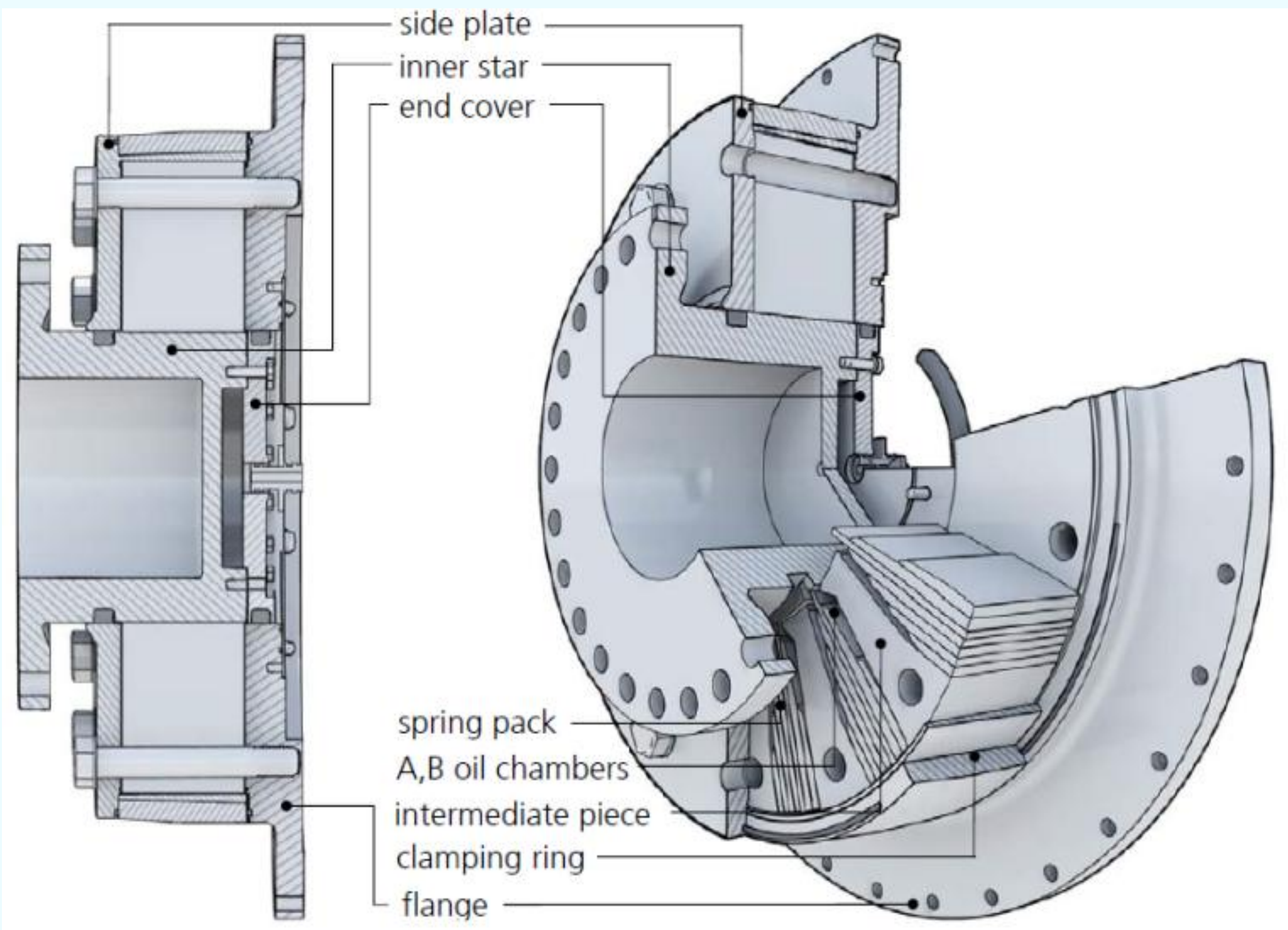

Figure 2: Coupling sectional view

Modeling

The coupling is regarded as two rotating masses, the outer and the inner wheel, that are connected by the springs. There are twelve identical segments in the coupling. Each consists of 2 springs, 3 oil chambers of which to are connected by a small groove and a twist limiting bumper.

The springs are regarded as cantilevered beams. They are fixed with one end to the outer wheel and transmit the power as a tip load to the inner wheel. On their flanks, the pressure from the oil chambers acts as a line load.

The resulting bond graph can be seen in figure 3.

This model is then excited by an input force to investigate the dynamic response. The simulation results show that the coupling is much stiffer than the values provided by the manufacturer (Figure 4). The reason for this is still investigated. Further results show that the coupling doesn't damp well for lower excitation frequencies but shows better results for higher frequencies. This could be suitable to damp the forces from the combustions in the engine.

Afterwards the coupling model is inserted into a provided drive train model. The drive train consist of a two stroke engine with 6 cylinders and a propeller. The shaft torsion is neglected.

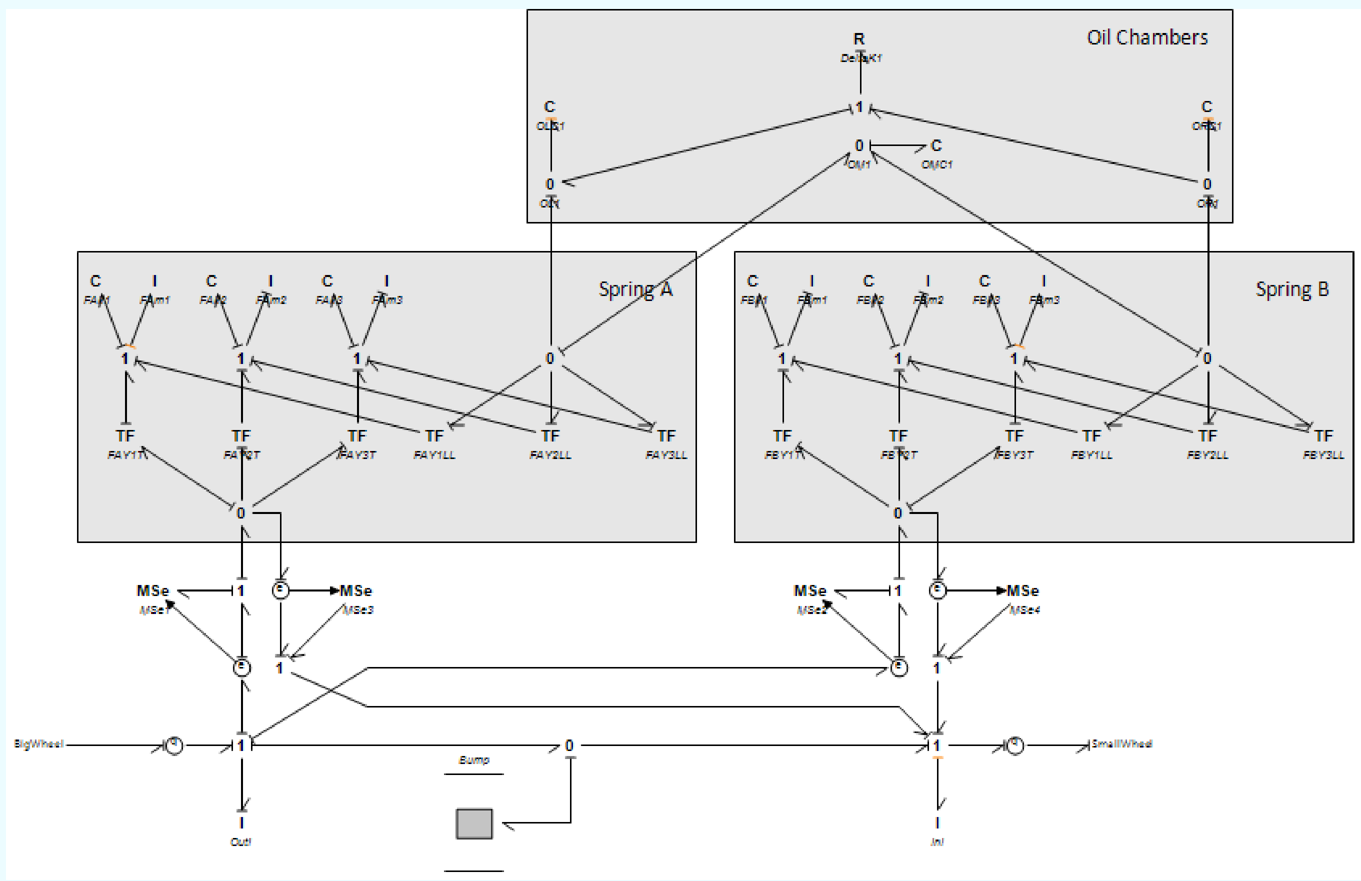

Figure 3: Bond graph model coupling

Results

First the coupling is simulated without the drive train. Figure 4 shows the twist difference between the input (engine) side and the output side of the coupling. The simulation shows that the difference and therefore the damping is minimal.

Then the coupling is inserted into the drive train Figure 5 shows the twist difference in that case. Finally the ice impact load on the propeller is added to the model (Figure 6). The simulations show that the twist difference is proportional to the force acting on the coupling. The behavior of the engine changes due to the larger resistance of the propeller due to the ice impact.

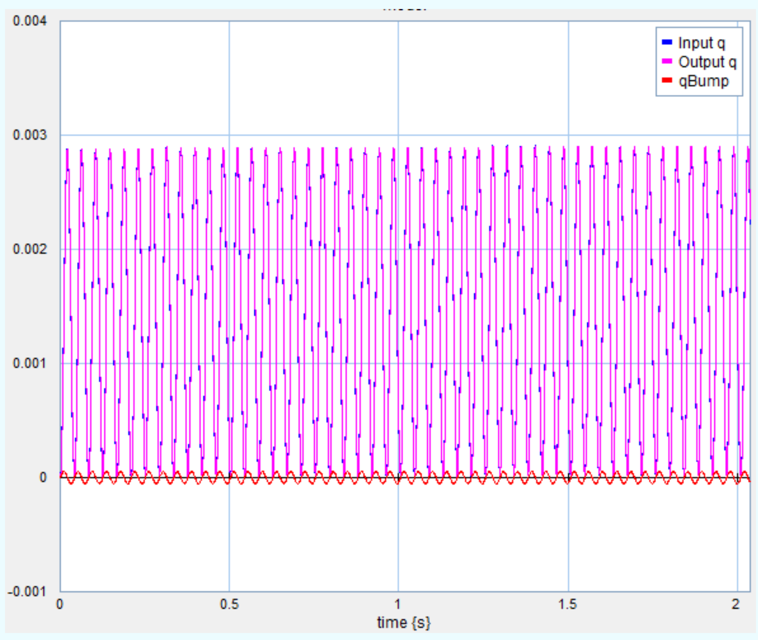

Figure 4: Twist difference in coupling with sinus excitation

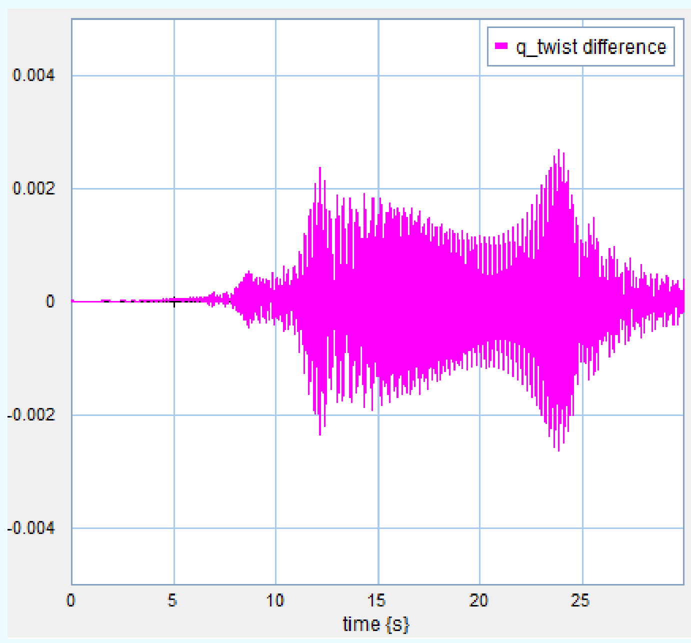

Figure 5: Drive train simulation. Twist difference across coupling without ice impact.

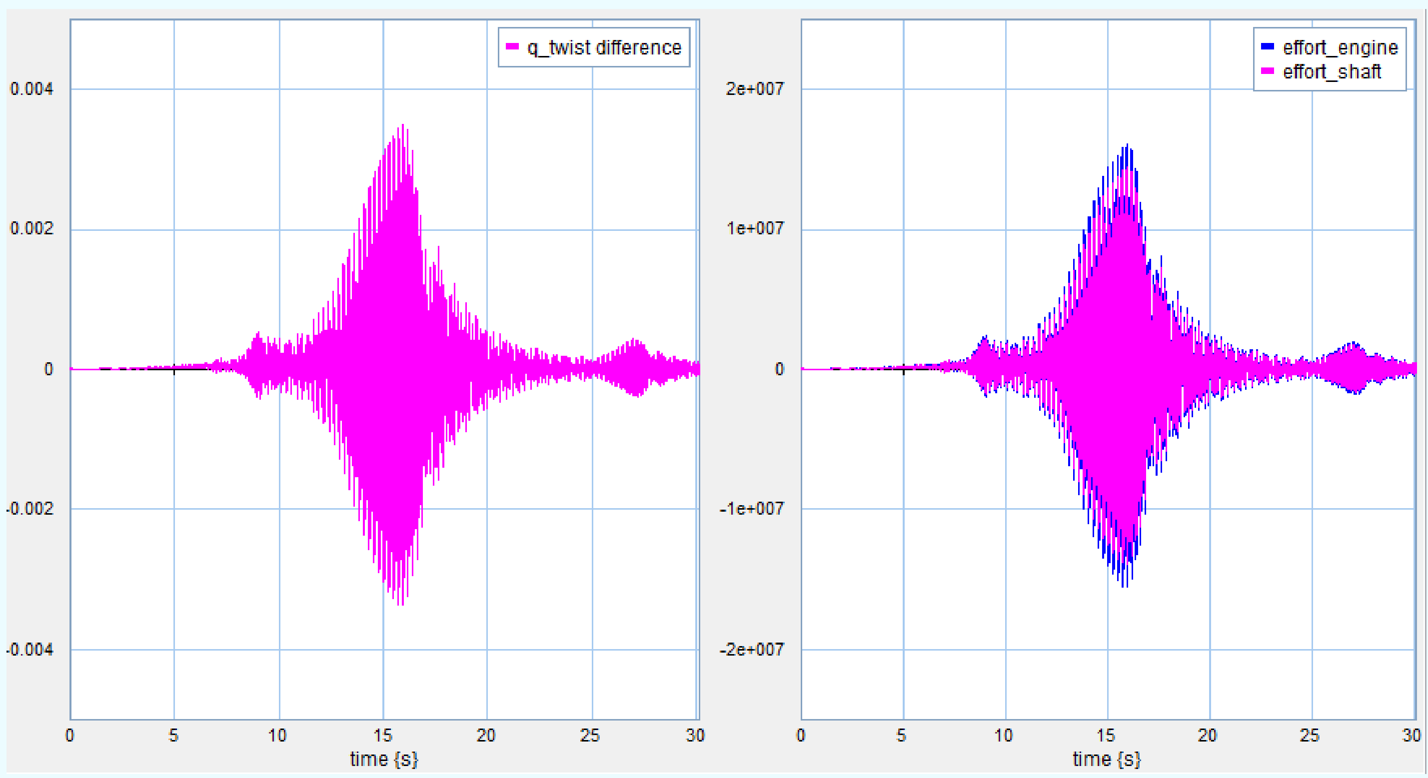

Figure 6: Drive train simulation result. Twist difference [rad] and input and output force [N] of the coupling with ice impact

Conclusion

The preliminary results show that the coupling in the present state is much to stiff. This needs further investigation. The fact that the damping is dependent on the frequency of the excitation force seems reasonable. This behavior would not be shown by a simplified coupling model. Some adjustment must be made to the coupling and the engine model and further research must be done on the on the behavior of the drive train model.