



18.01.2023

The influence of journal bearings on the drivetrain dynamics of a 5MW wind turbine drivetrain

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Research and service spectrum

Measurement of environmental conditions



Green hydrogen



Qualification of composite materials and components



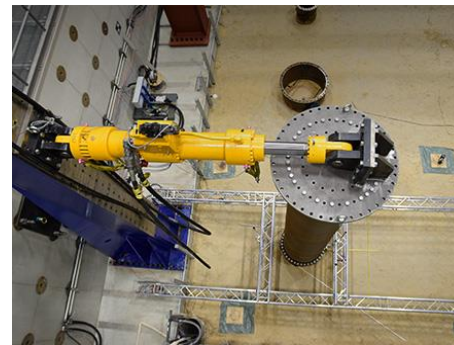
Examination of drive train and components



Certification of electrical properties



Validation of support structures



Nacelle Testing



New Design Solutions for Improving System Reliability

Roller bearings being replaced by journal bearings

- Roller bearings are facing reliability issues
- Theoretically, journal bearings have infinite bearing life
- They have good vibration damping characteristics
- They offer a high dynamic and static load capacity for same dimensions as roller bearings



Source: www.winergy-group.com

New Design Solutions for Improving System Reliability

Roller bearings being replaced by journal bearings

- Gearbox bearings have shown reliability issues in past years
- New gearbox designs are incorporating journal bearings
- Theoretically, journal bearings have infinite bearing life
- They have good vibration damping characteristics
- They offer a high dynamic and static load capacity for same dimensions as roller bearings

By direct replacement of roller bearings with journal bearings without any major design changes;

- Influence on vibration?
- Influence on the gear teeth forces?



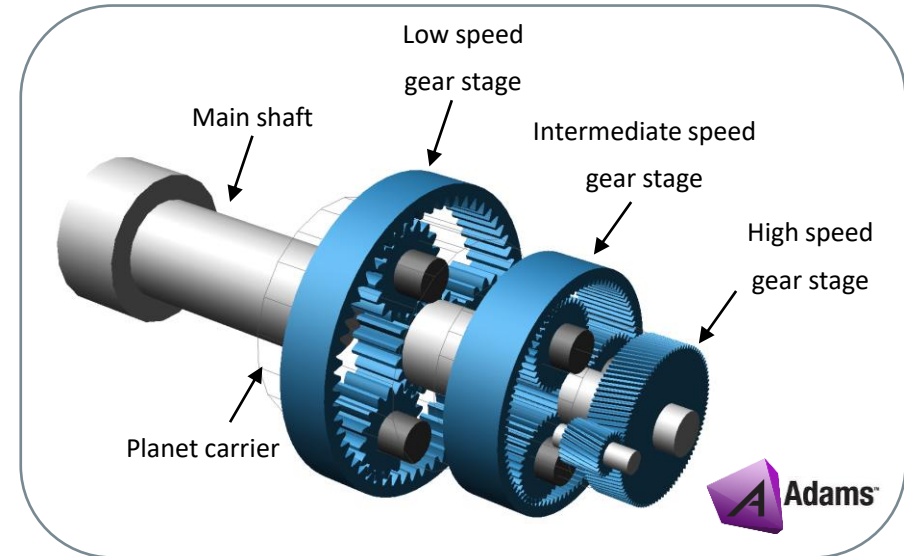
Source: www.winergy-group.com

Wind Turbine Drivetrain Model

MBS model of the 5MW reference drivetrain

- 5MW Drivetrain¹ designed for the NREL 5MW offshore reference wind turbine
- Multiple gear stages

Drivetrain Features	Value
Total gear ratio	1:96.354
Designed Power (MW)	5
Rated input shaft speed (rpm)	12.1
Rated generator shaft speed (rpm)	1165.9
Rated input shaft torque (kN.m)	3946
Rated generator shaft torque (kN.m)	40.953



1. Amir R. Nejad et al. Development of a 5 MW reference gearbox for offshore wind turbines. Wind Energy, 2016.

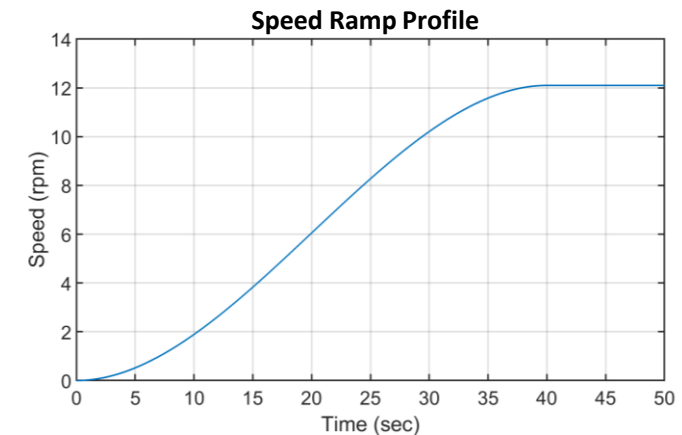
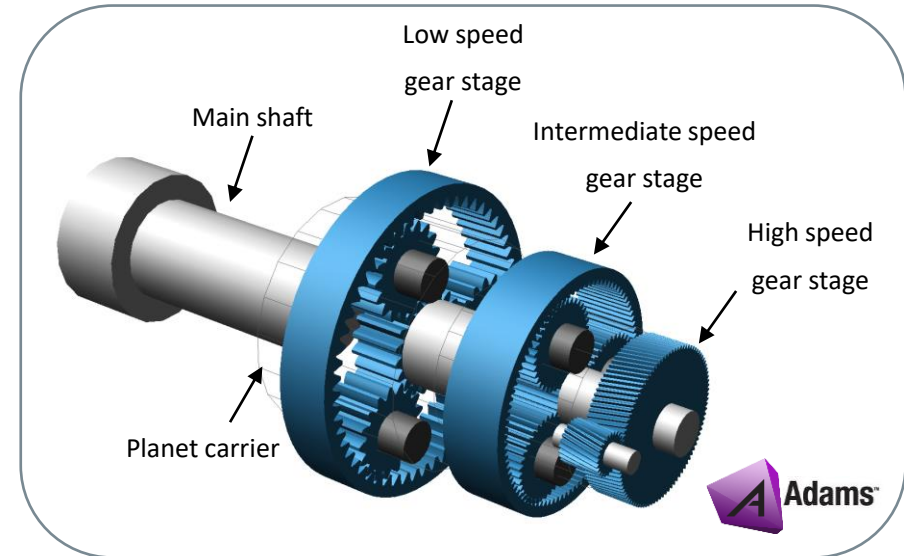
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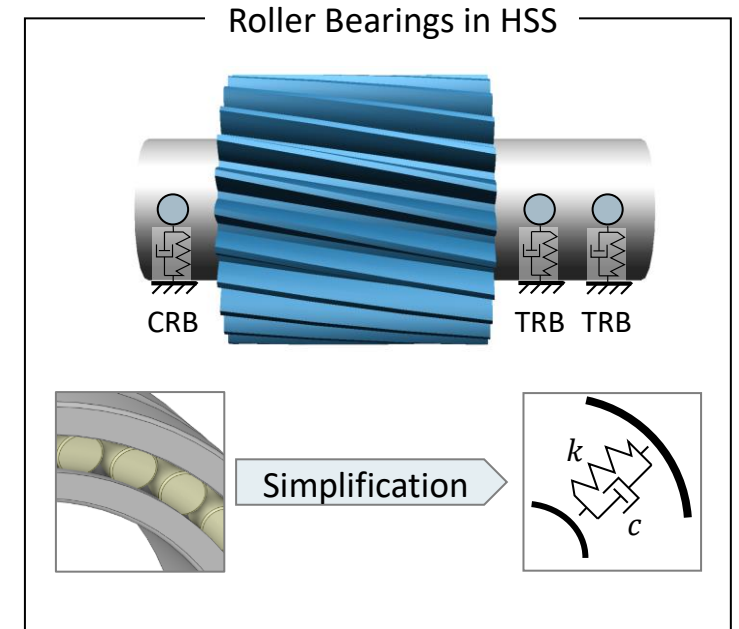
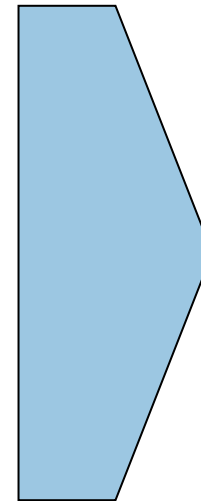
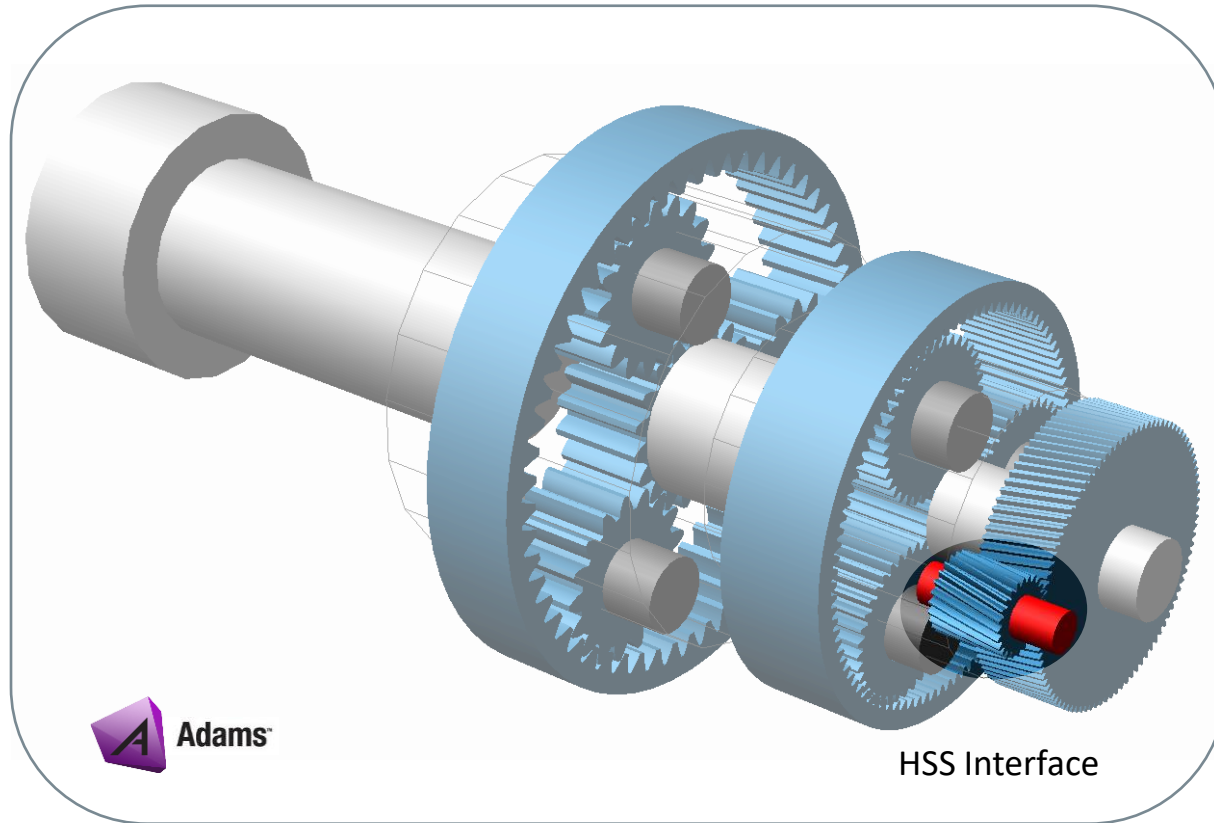
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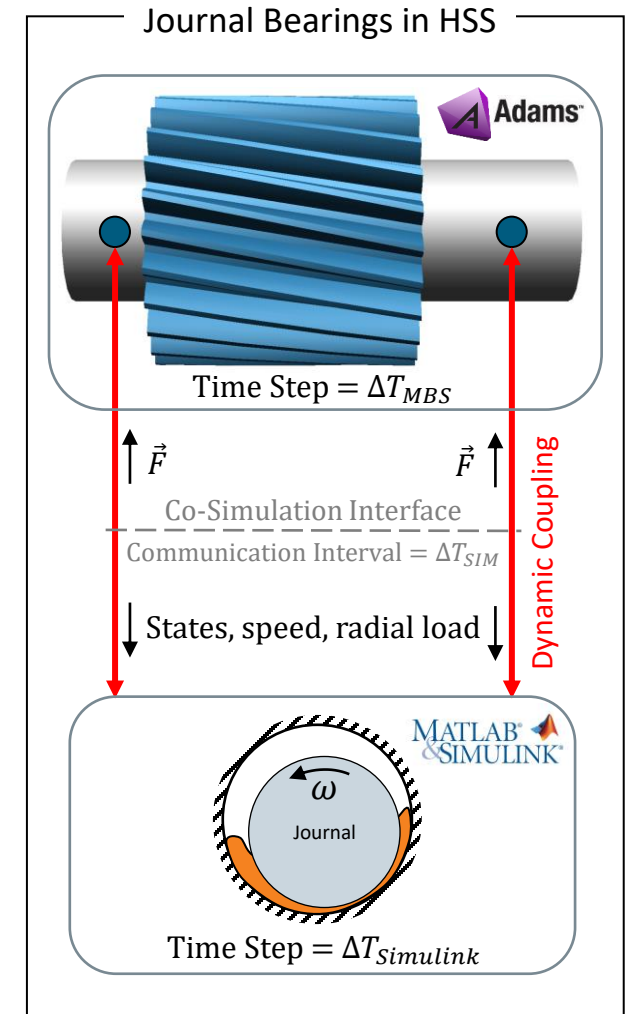
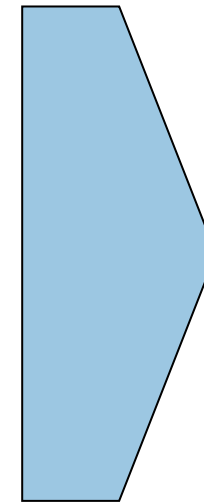
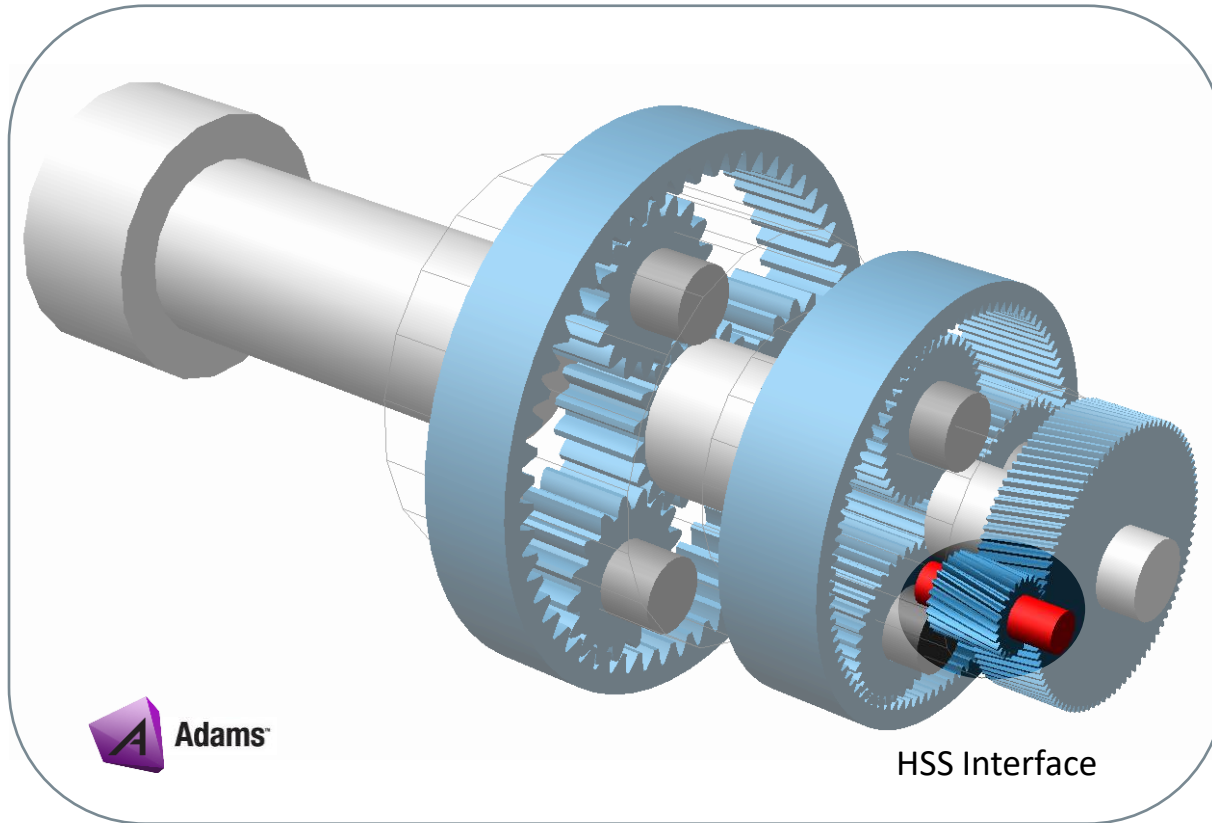
Model Variations for Case Studies

Case – 1 High speed shaft is supported by roller bearings



Model Variations for Case Studies

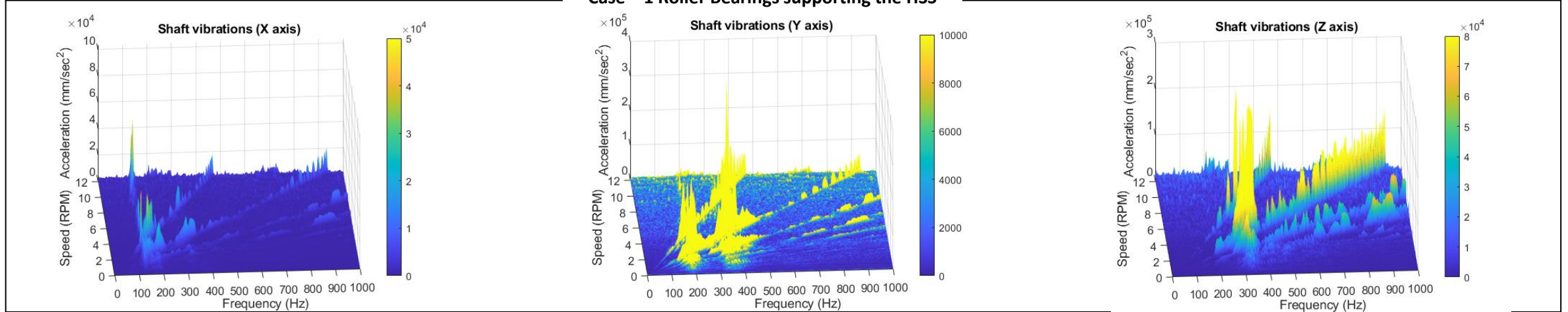
Case – 2 High speed shaft is supported by journal bearings



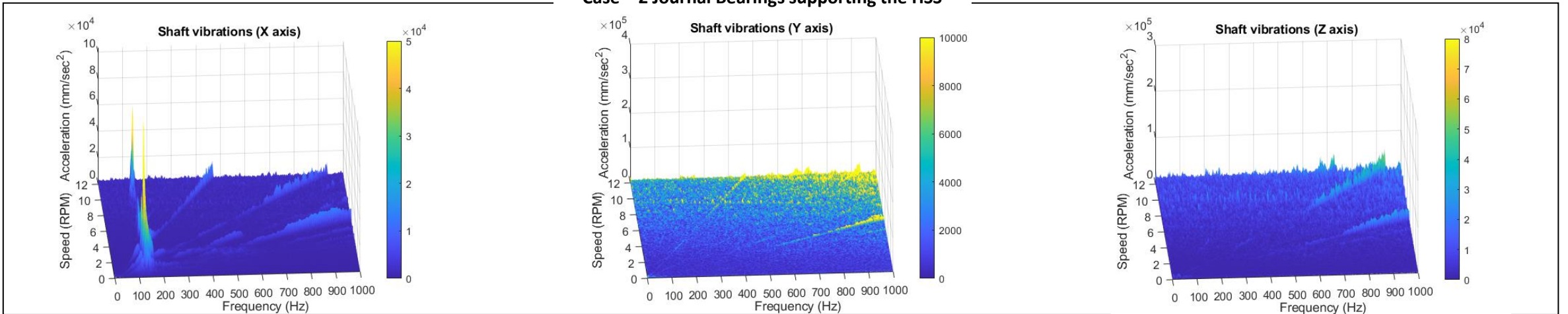
Results

Comparison of high-speed shaft vibrations

Case – 1 Roller Bearings supporting the HSS

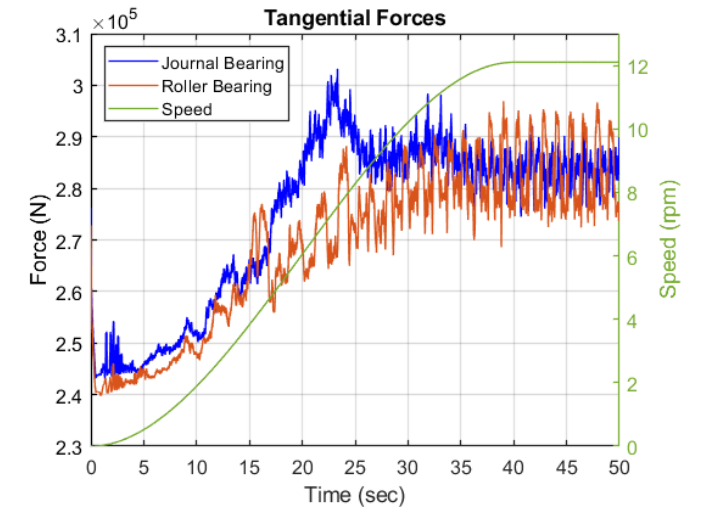
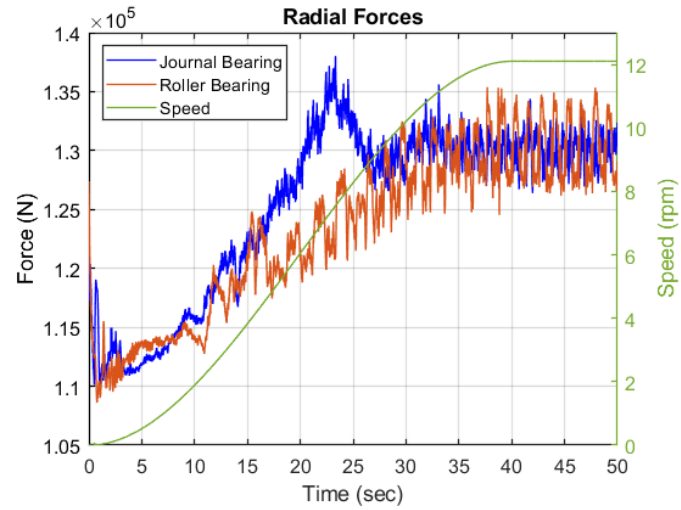
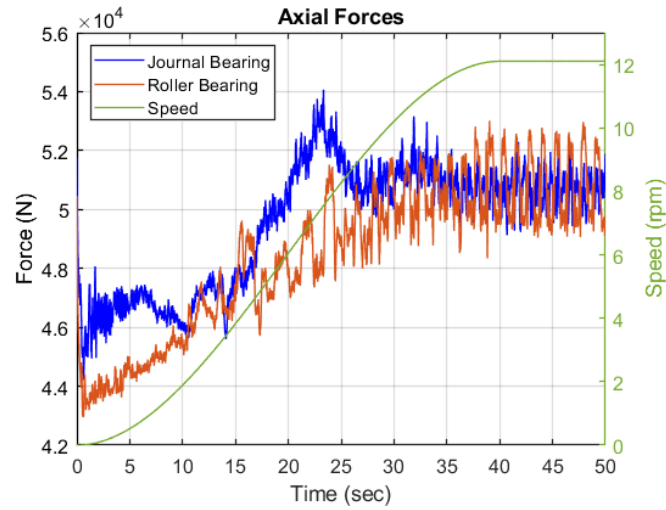


Case – 2 Journal Bearings supporting the HSS

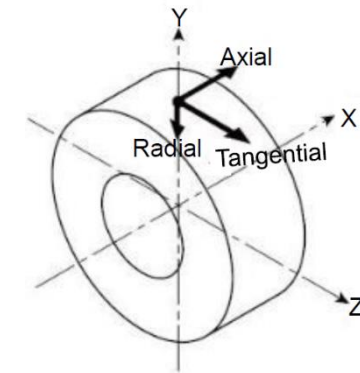


Results

Comparison of gear teeth forces

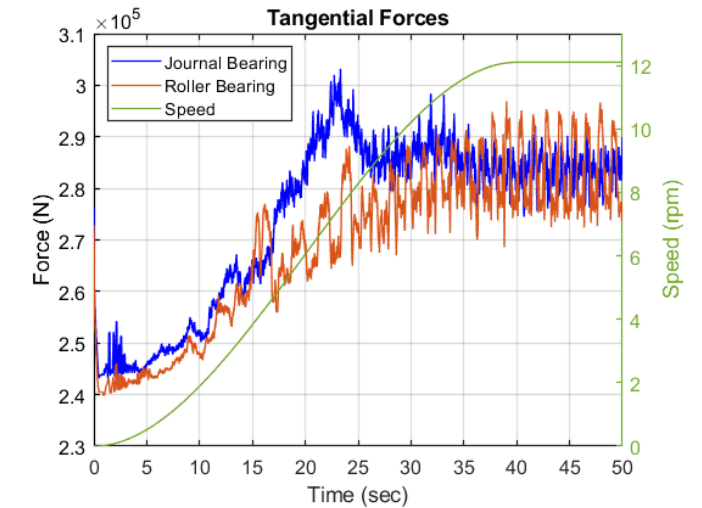
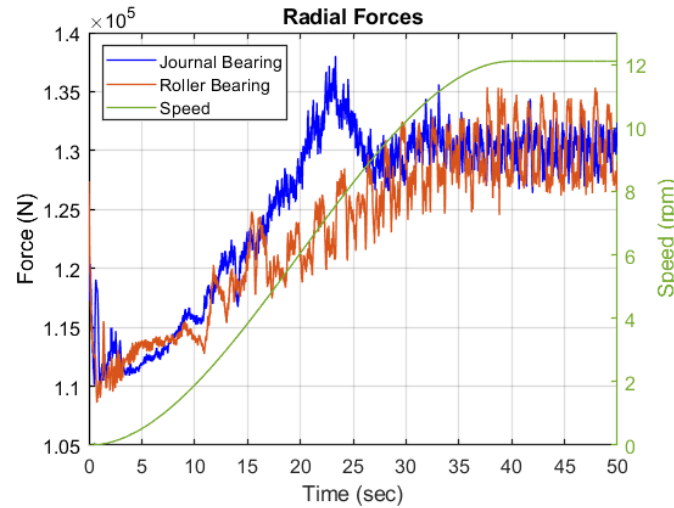
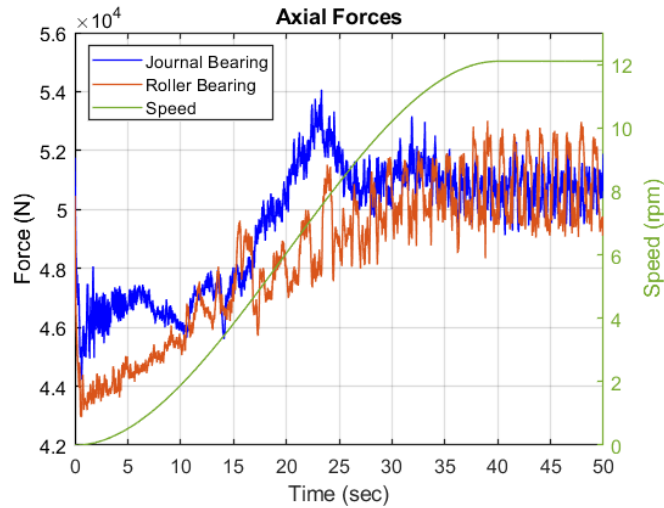


- Higher gear forces at sub-rated speeds when journal bearings replaced the roller bearings

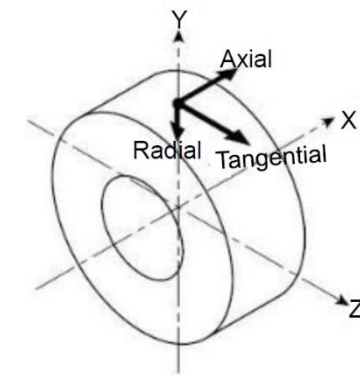
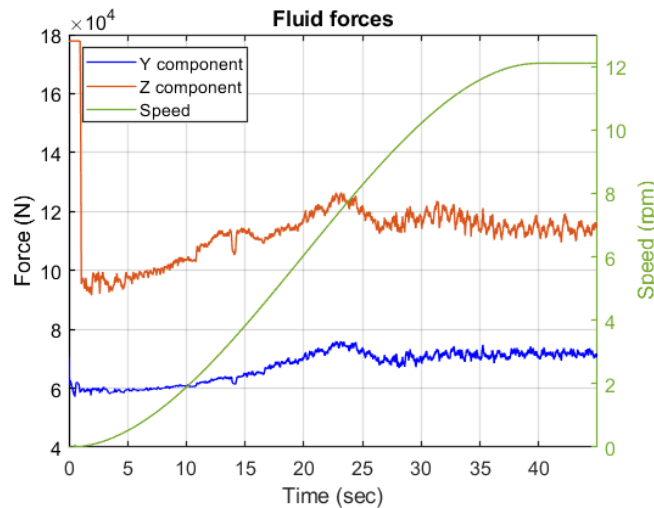


Results

Comparison of gear teeth forces



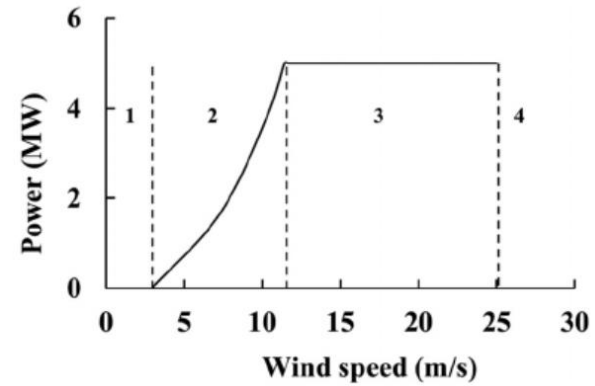
- Higher gear forces at sub-rated speeds when journal bearings replaced the roller bearings
- Higher fluid forces generated by the journal bearing model at sub-rated speeds



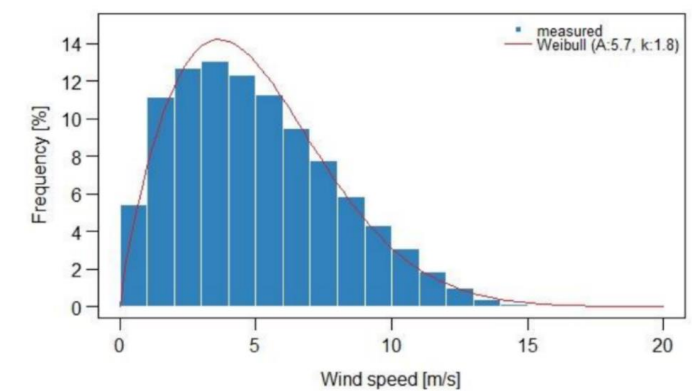
Discussion

- The rise of the gear forces at sub rated speed in journal bearing based model can likely lead to higher contact stress and root stress of gears which can affect the gear reliability.

Typical power curve of a wind turbine²



Typical wind speed distribution³



2. Thakur et al. Load Mitigation Using Slotted Flaps in Offshore Wind Turbines. Journal of Offshore Mechanics and Arctic Engineering, 2018

3. Matthew et al. Urban wind resource assessment: a case study on cape town. Energies, 2019

Conclusions and Future Work

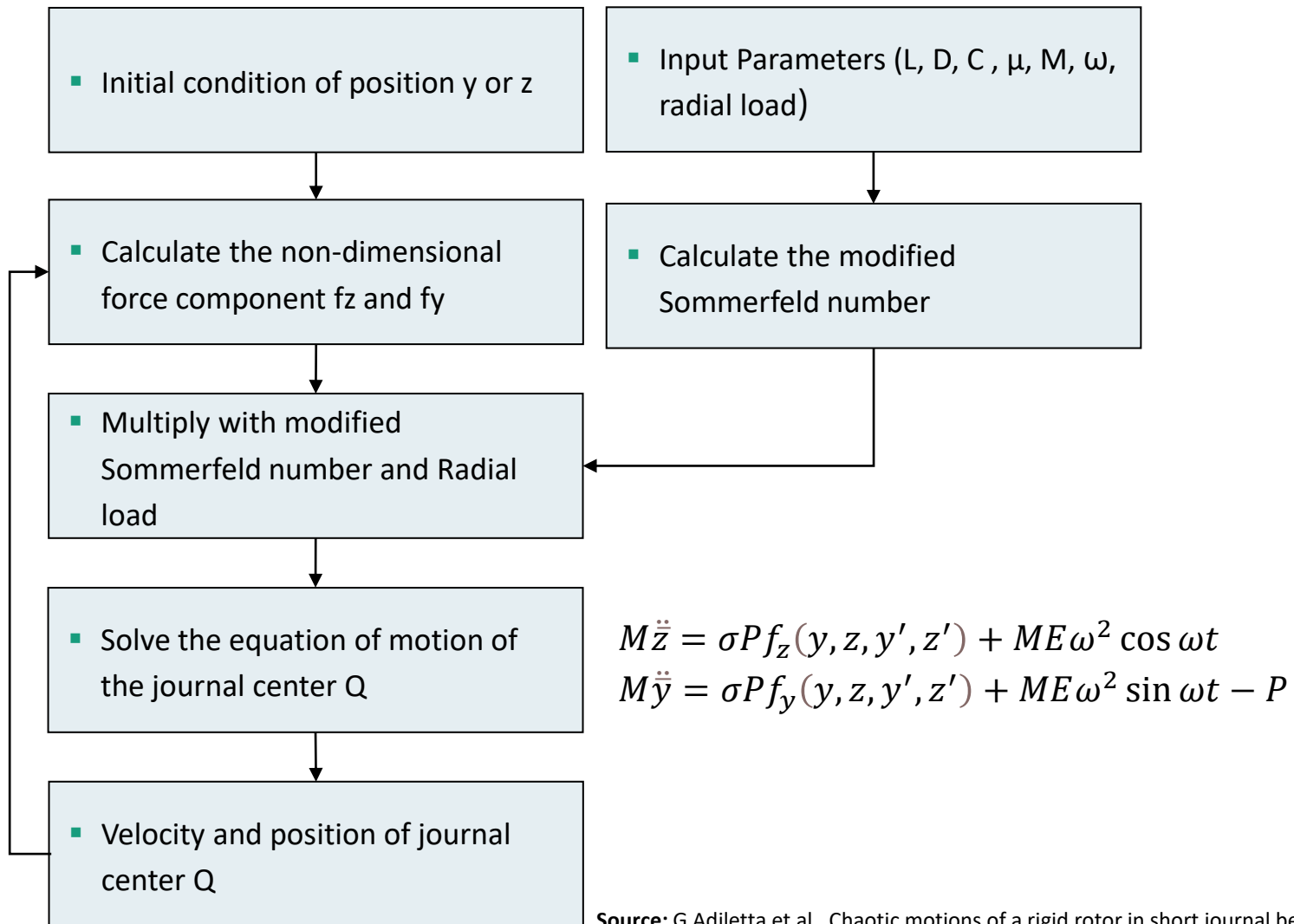
- Simulation based investigation was performed in gearbox with roller bearing model and gearbox with journal bearing model
- The special vibrations of the high-speed shaft were lowered in the journal bearing based gearbox model relative to gearbox with roller bearing
- It was observed that the gearbox with journal bearing lead to higher gear forces in sub-rated speed regions
- Future work may involve replacing the roller bearings of planet gears with journal bearings and analyze the system response.
- Using different tests in future (FRT, shock tests)



Thanks a lot for
your attention!
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Appendix - Journal Bearing Model



Source: G Adiletta et al., Chaotic motions of a rigid rotor in short journal bearings. Nonlinear dynamics, 1996.

