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# Dynamics Simulation and Malfunction Diagnosis of Heavy Machinery Using MSC ADAMS

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# 1. Introduction

- Large mining excavators are widely used in open pit mining industry for loading and excavating operation. Electric shovel is one of this kind of heavy machinery and its weight can be as high as hundreds to thousands tons. This study demonstrates the efficacy of using MSC ADAMS software for dynamics simulation and malfunction diagnosis of a large mining excavator.

# 2. Modeling the Electric Shovel



Swing Bearing

Crawler Travelling System
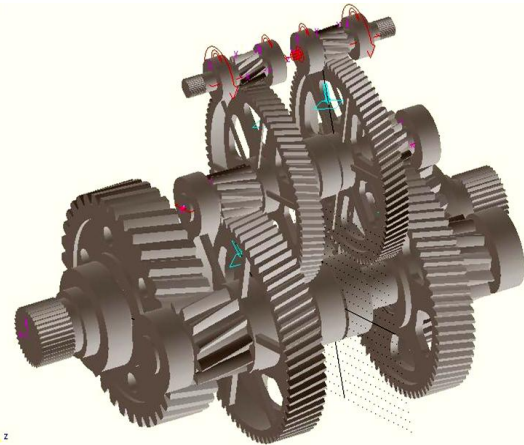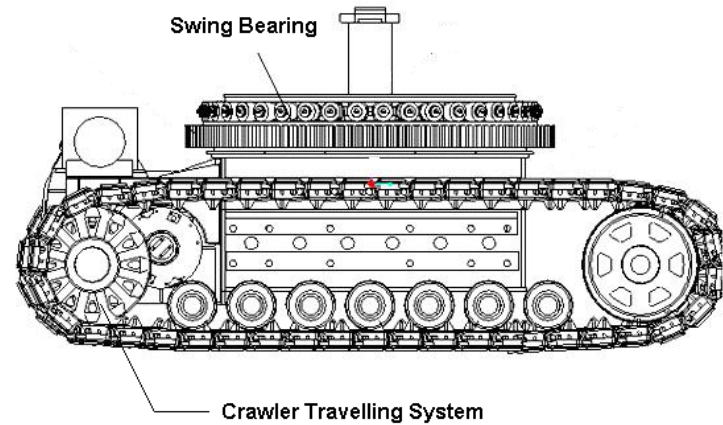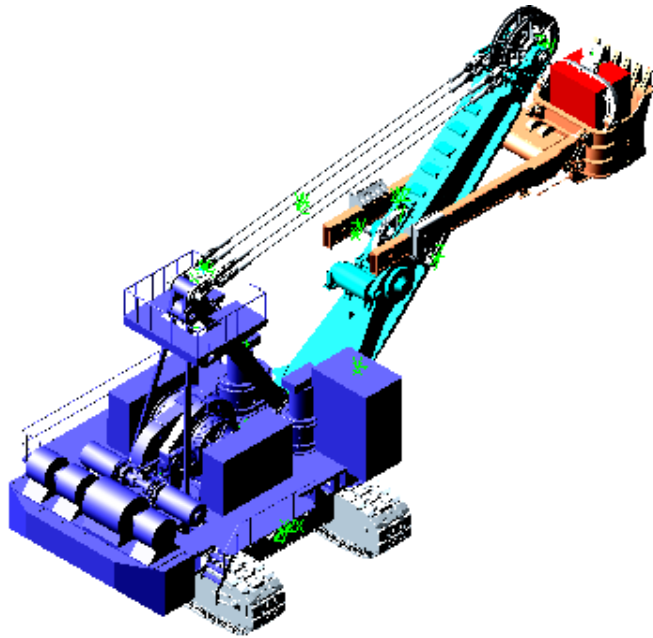
- 3-D CAD model is created for ADAMS simulation

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# 3. Dynamics Simulation for Swing Bearing
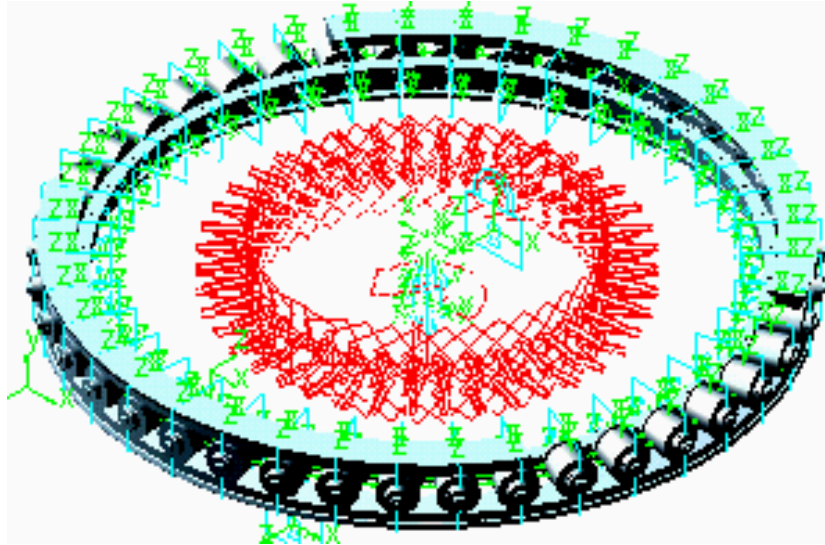


To perform simulation, the driving torque and braking torque are applied to the upper structure along with the upper tracks, and the contact forces are applied between rollers and tracks.

# Simulation Results:

- Swing motion diagrams of the upper structure, including angular velocity and acceleration in a loading cycle

- Contact forces between the rollers and tracks

# 4. Dynamics Simulation of the Crawler Travelling System

- The driving torque from the traveling gearbox is applied to the crawler driving tumbler, and the resistant force is applied to the chassis frame. The joint or cylindrical constraints are applied between the wheels and the their shafts. The contact pairs are applied between the crawler shoes and the driving tumbler, the lower roller and the crawler shoes. The simulation results show the x, y, and z components of the contact forces between driving tumbler and the crawler shoes.
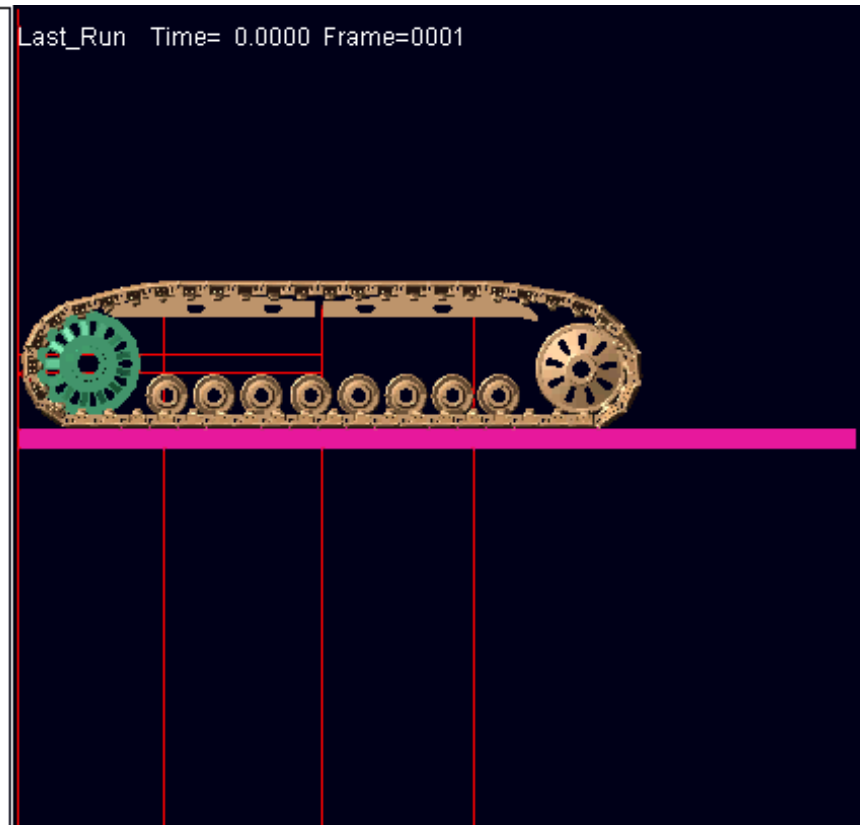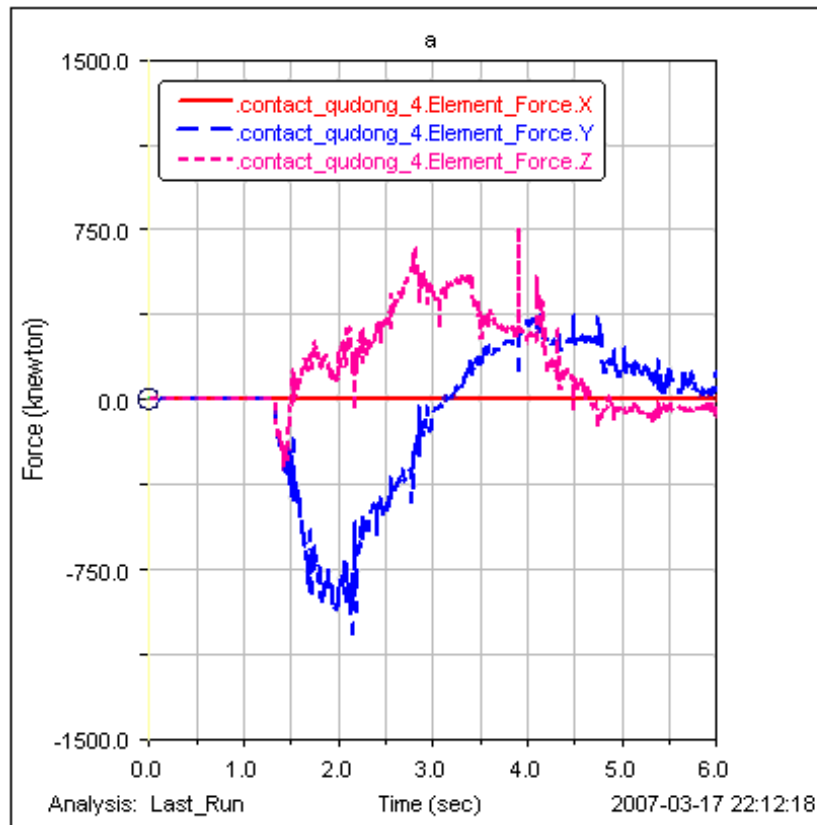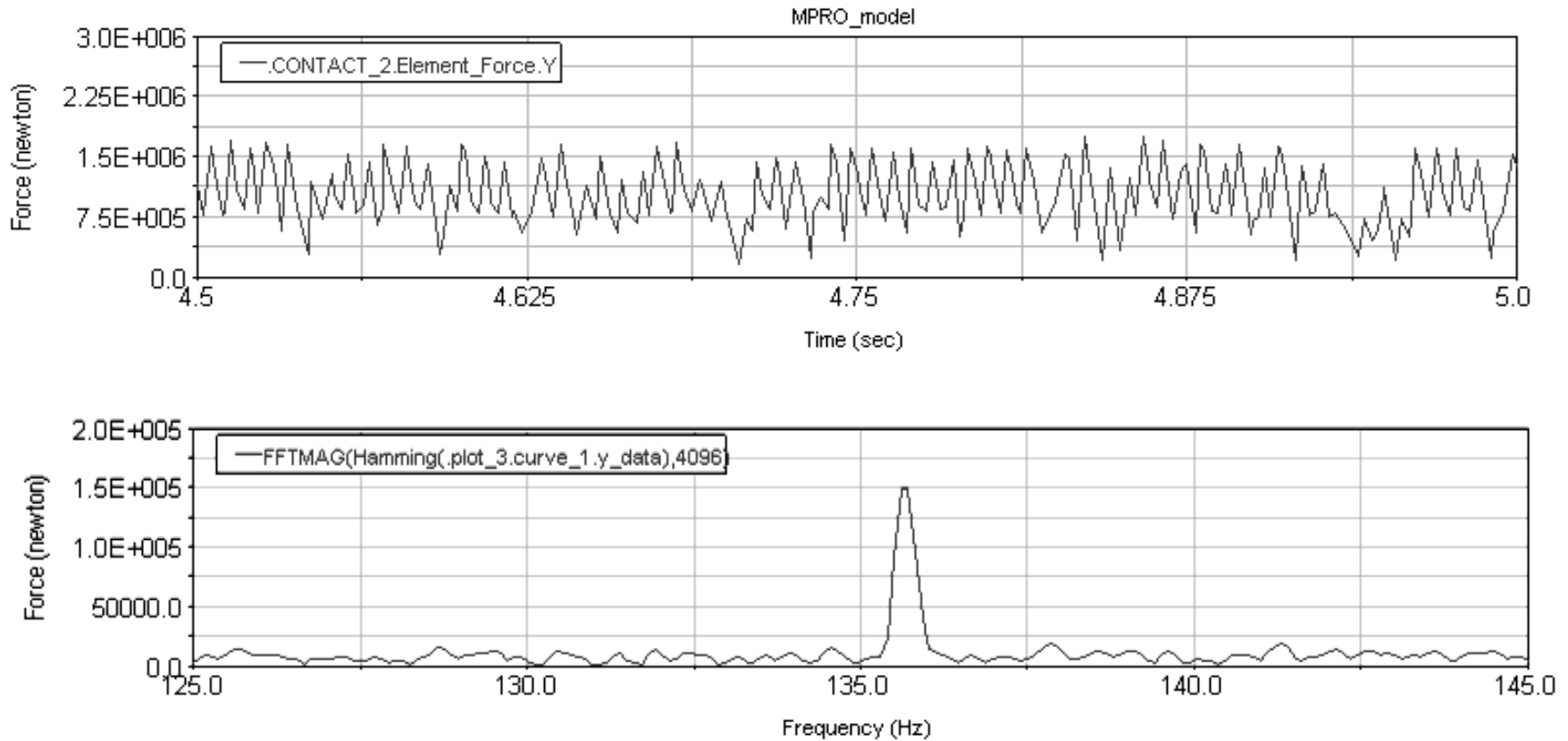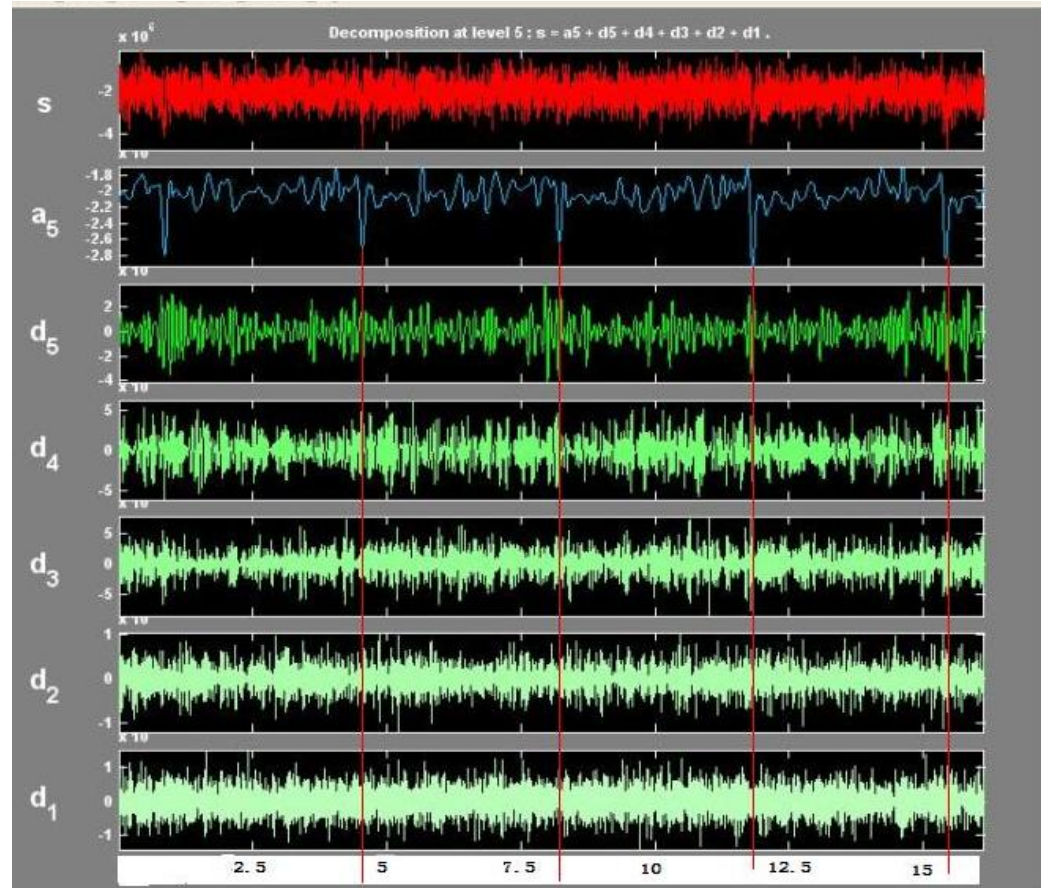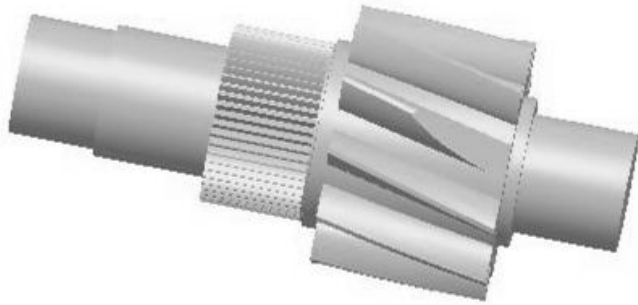
# Animation for the Crawler System Simulation

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# 5.Gearbox Dynamics Simulation and Fault Diagnosis
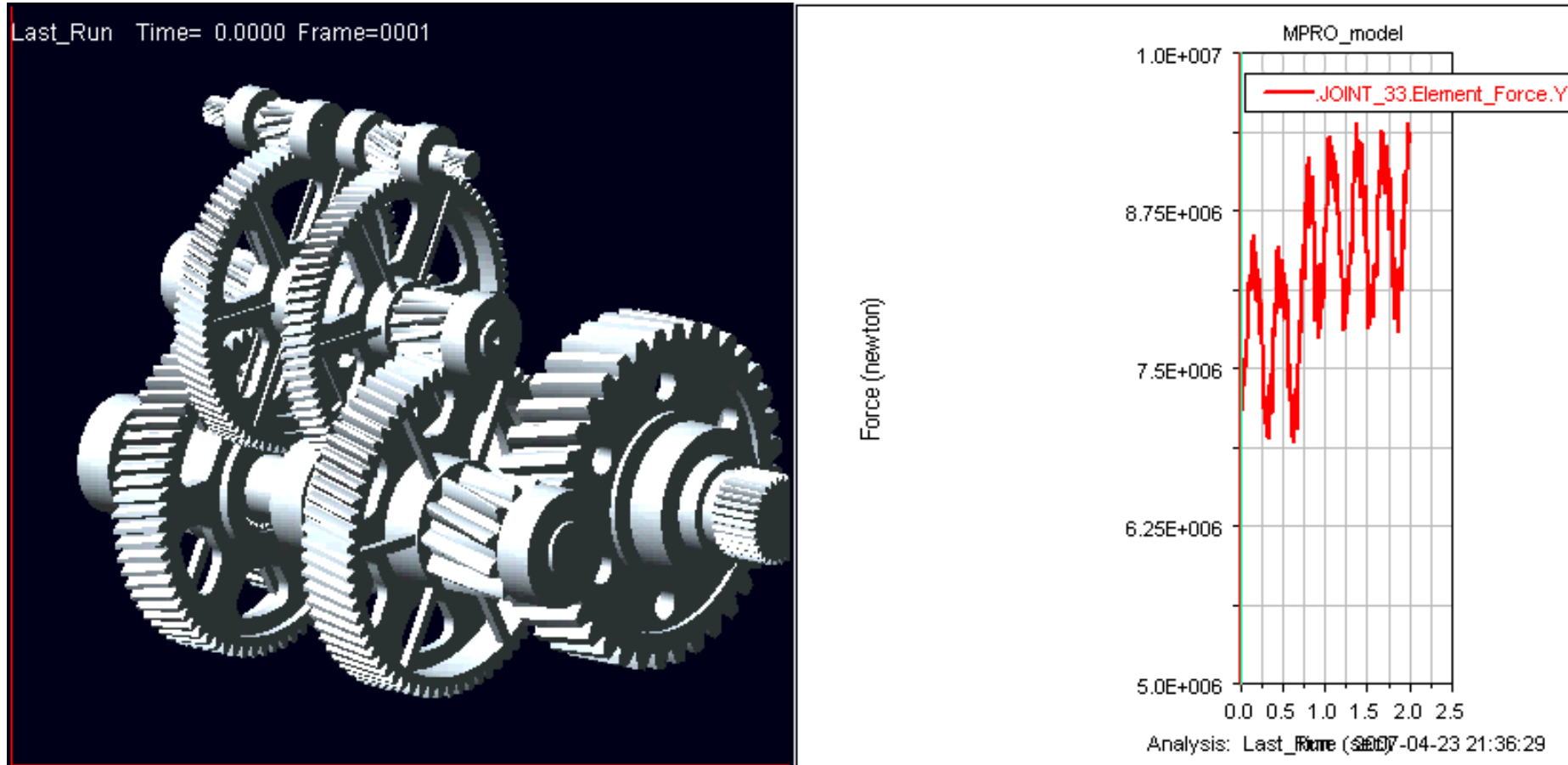


**The crawler travelling system is driven by a three-stage gear transmission.**

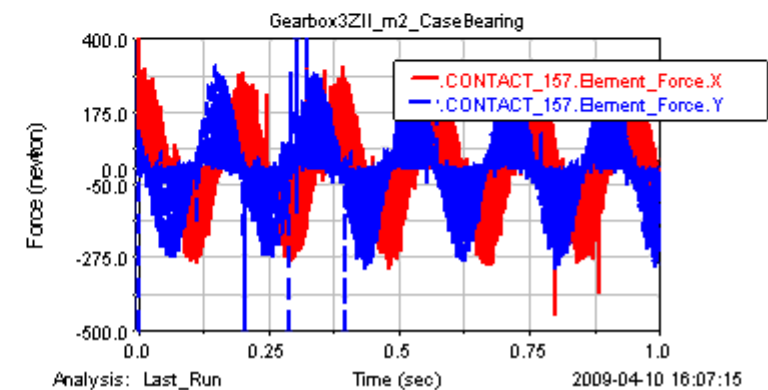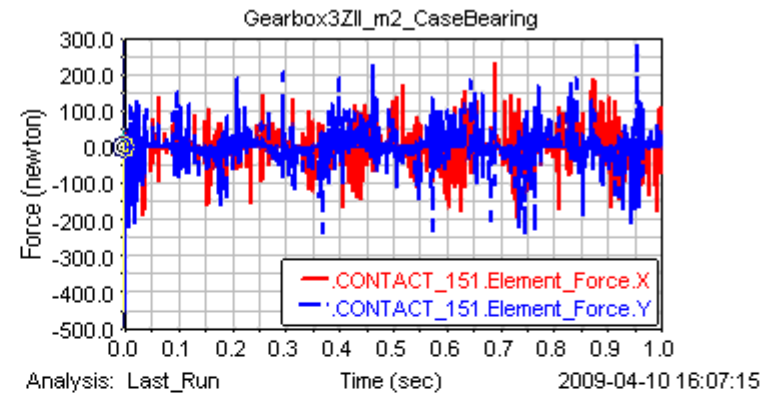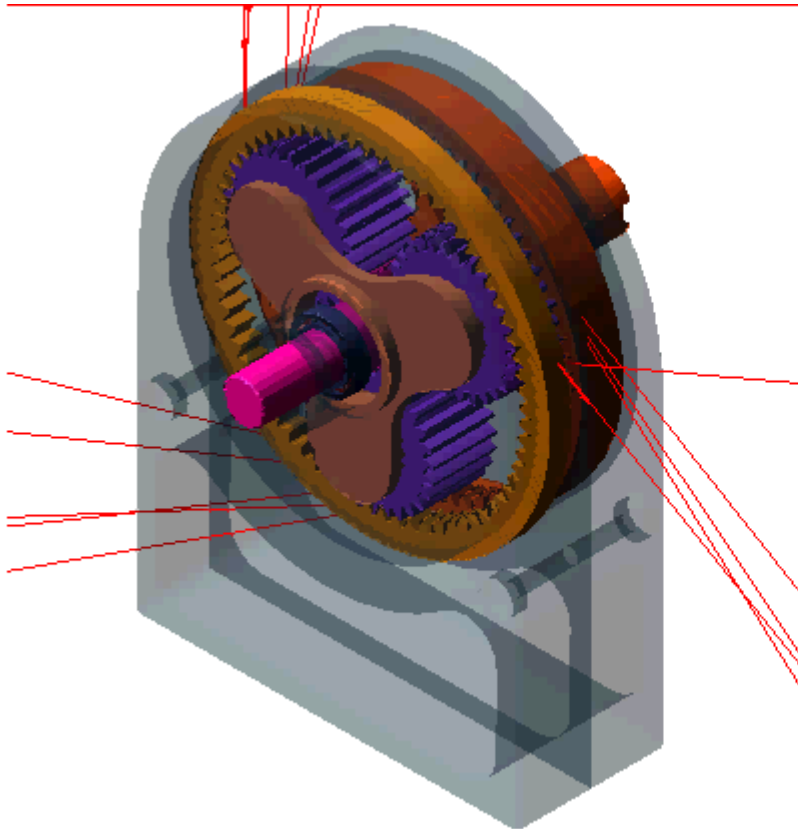- From the contact forces, we can get the meshing frequencies by FFT.

- To simulate the fault mode of gearbox, a pinion with chopped tooth joints in the ADAMS model, and the meshing frequency of the fault tooth of the pinion can be detected by wavelet transform after the contact force simulation.

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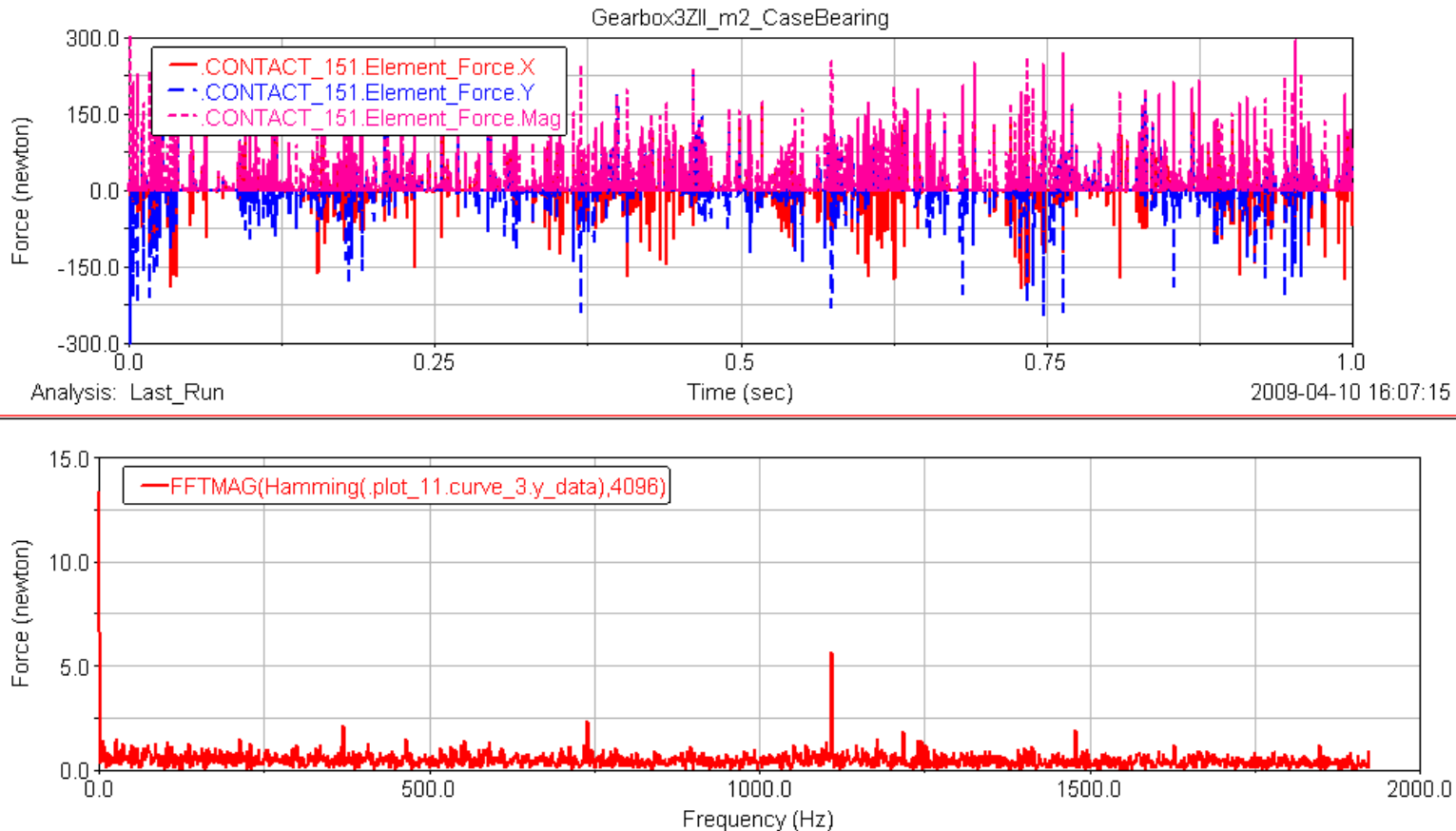# 6. Planetary Gearbox Dynamics Simulation and Fault Diagnosis
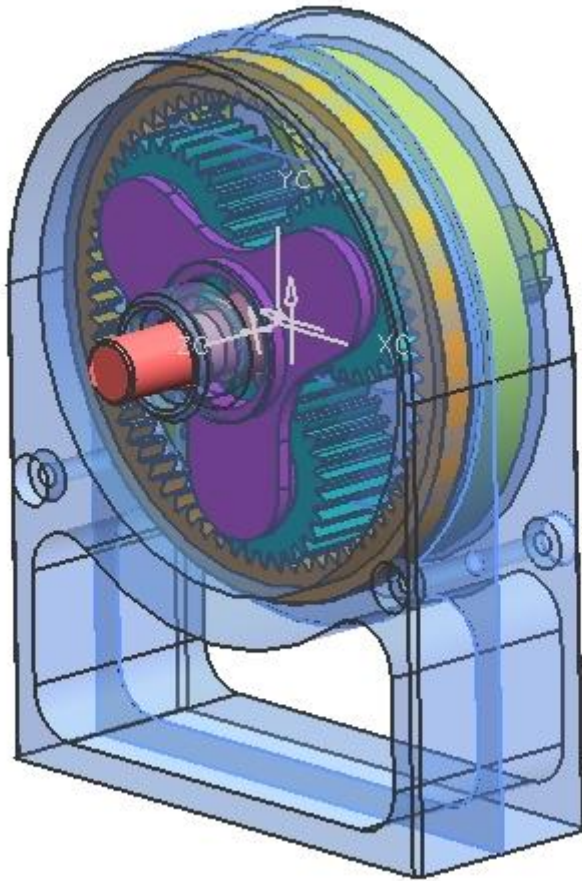


- This is a 3ZII type planetary gearbox with large gear ratio. Here is a scaled model with module 2 and gear ratio 134.
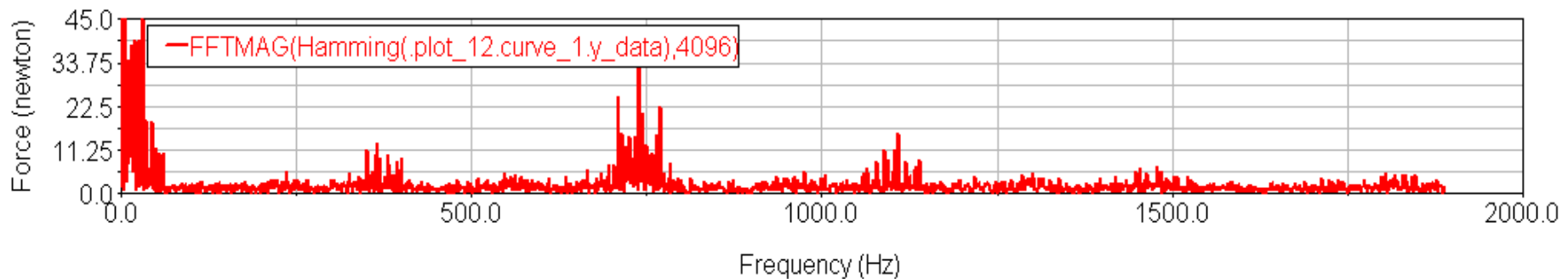
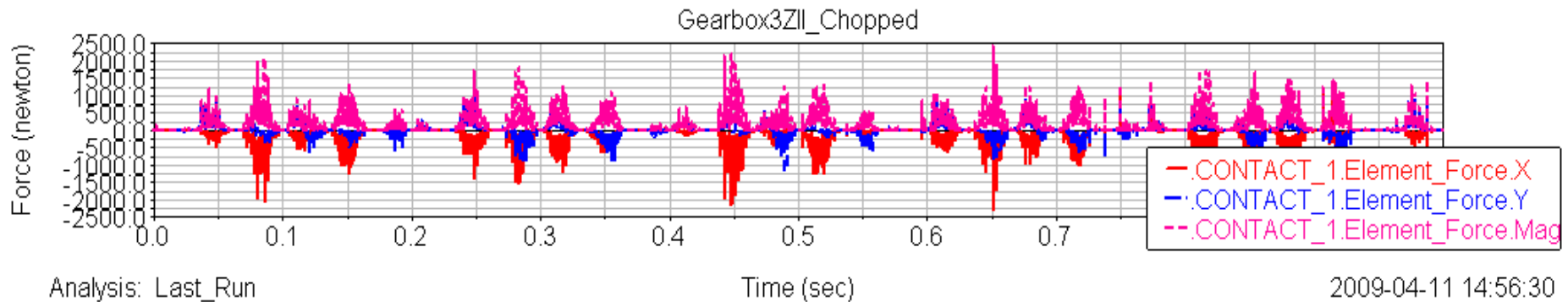# 6.1 Simulation for the Gearbox with perfect teeth

# Contact Force between sun gear and planet gear, and its FFT Plot



- The peaks in FFT plot shows the meshing frequencies and meshing stiffness frequencies.

# 6.2 Simulation for the Gearbox with chopped tooth on sun gear



- The FFT for the contact force shows the modulated side bands because of tooth malfunction.

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# 6.3 Simulation for the Gearbox with Chopped Tooth on Sun Gear and Planet Gear
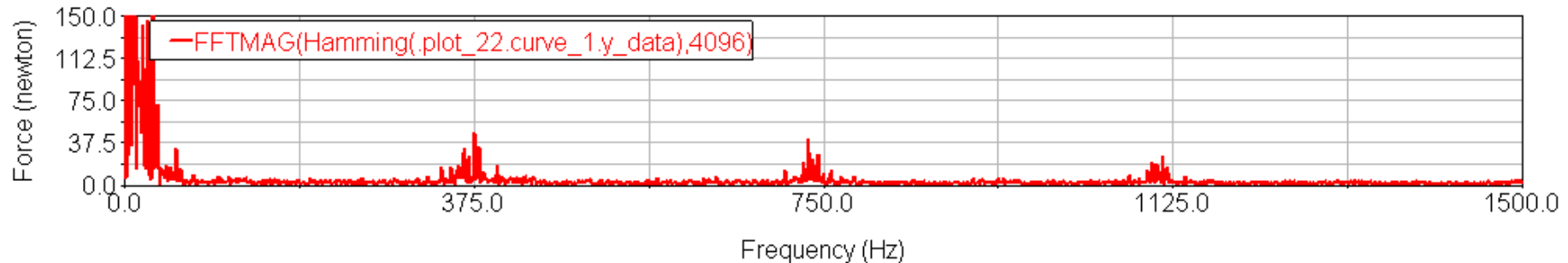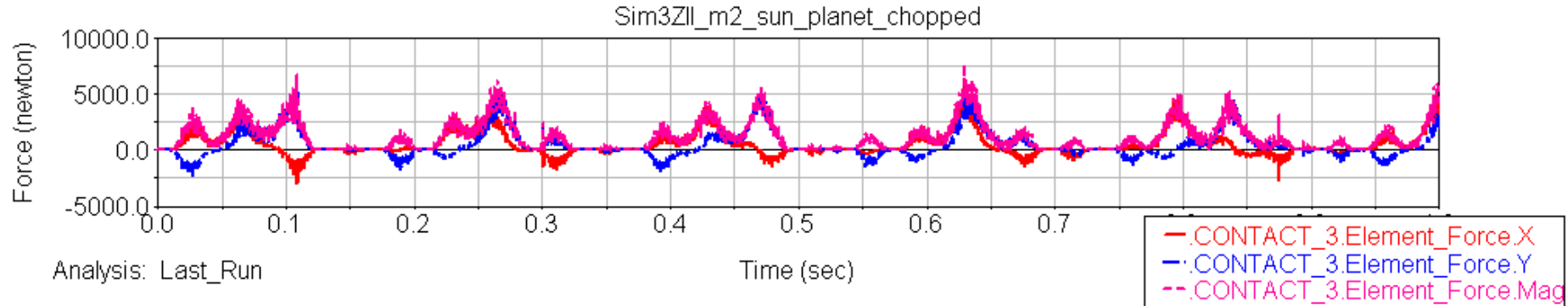


- The hunting tooth frequency shows up when teeth malfunction occurs on both pinion and gear.

# 7. Conclusion

- The VPD technology can largely reduce the heavy machinery R&D cost by cutting down some of the physical test on site.

- The simulation results revealed dynamics performance of the huge machine in several working conditions.  By post-processing the results of the dynamics simulation, techniques for gearbox malfunction diagnosis are possible.

- The signatures for gear faults can be obtained by FFT and wavelet transform.

# Thank you for your patience!

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