engineering. education. enterprise.
e=MSC 2009VPD virtual product development conference

Integrating ADAMS Software into an Upper Division Mechanical Design and Analysis Cours

Xi Wu, Assistant Professor, **California Polytechnic State University**

Dewen Kong, Professor, Jilin University

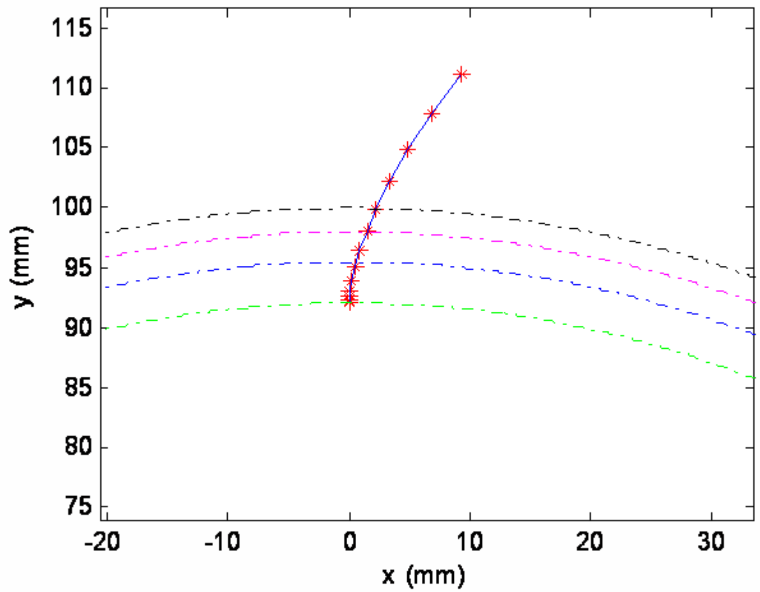
Jim Meagher, Professor, California Polytechnic State University

MSC Software

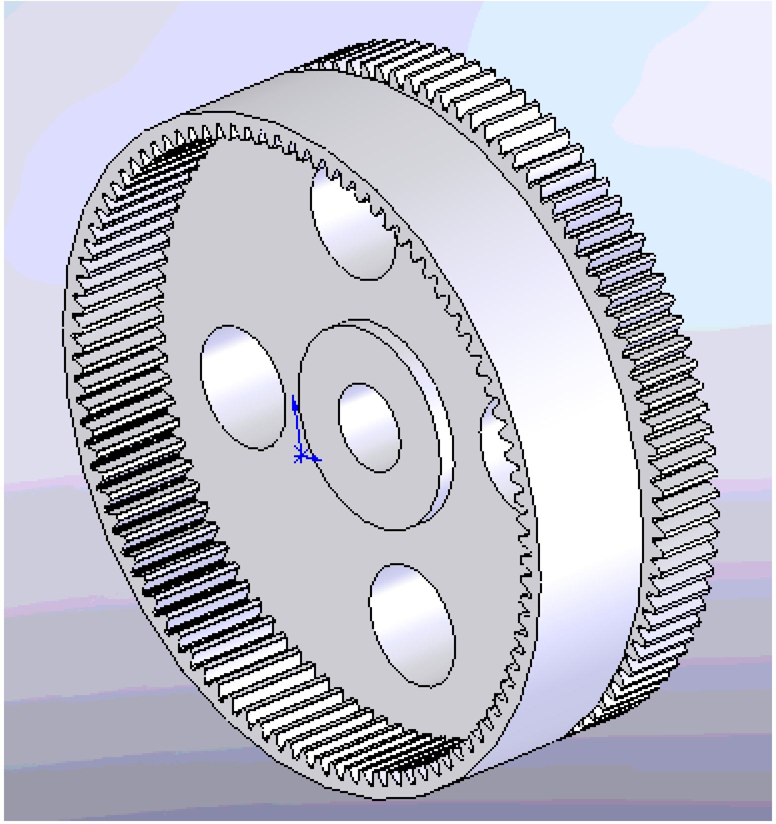
Outline

- Introduction to rotating machinery design and analysis course: ME518.
- Gear profile design using MATLAB and CAD program.
- Crank-slider mechanism and two-stage gear box.
- Three types of planetary gear transmission systems.
- Comparison of the ADAMS simulation results with theoretical results.
- Vibration signals synchronous with gear mesh frequency and input speed.
- Changes in vibration signatures due to damage in transmission components.

Gear Tooth Profile Design

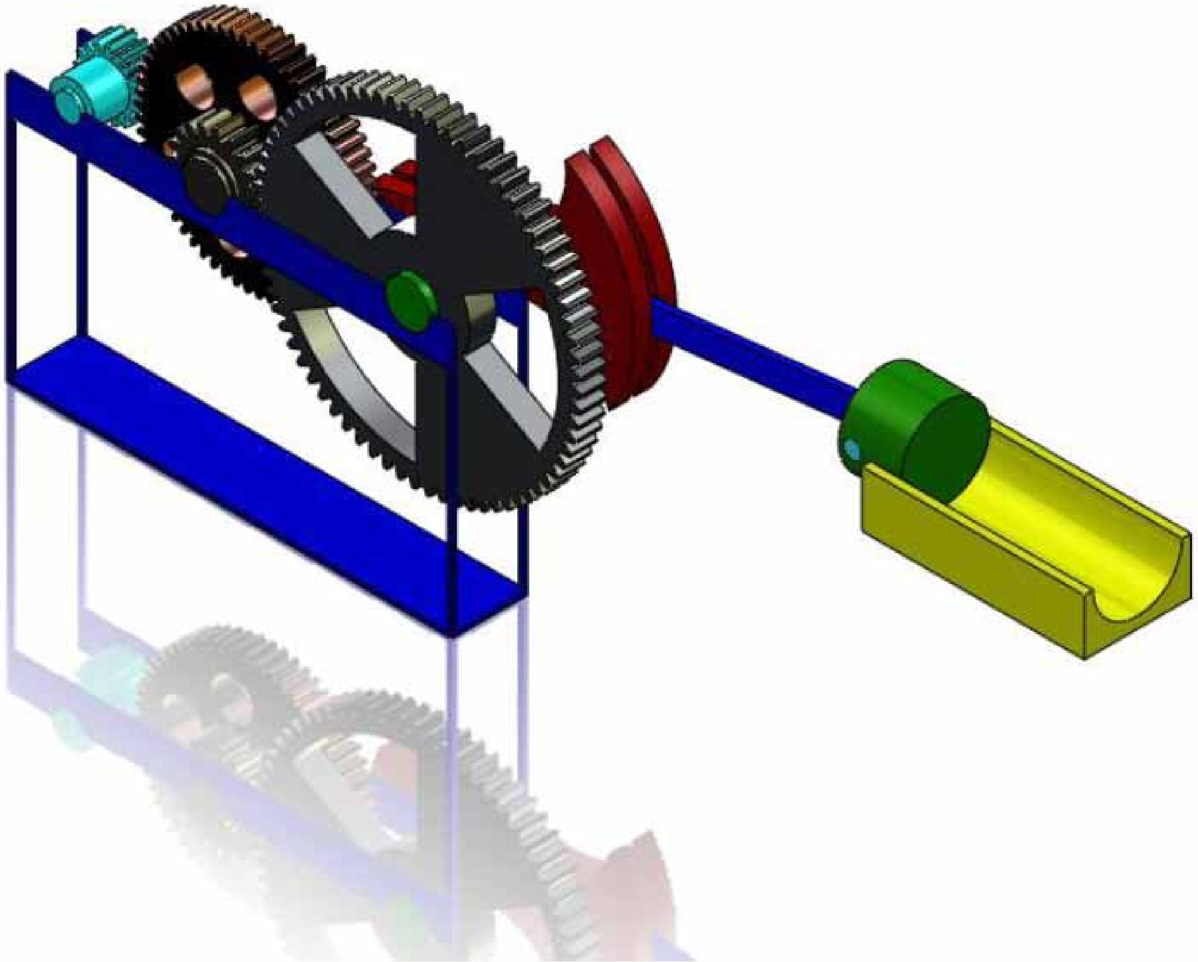


MATLAB plot for gear tooth profile



Note: In order to generate external tooth and internal tooth, respectively, the profile should be rotated different angles in different directions.

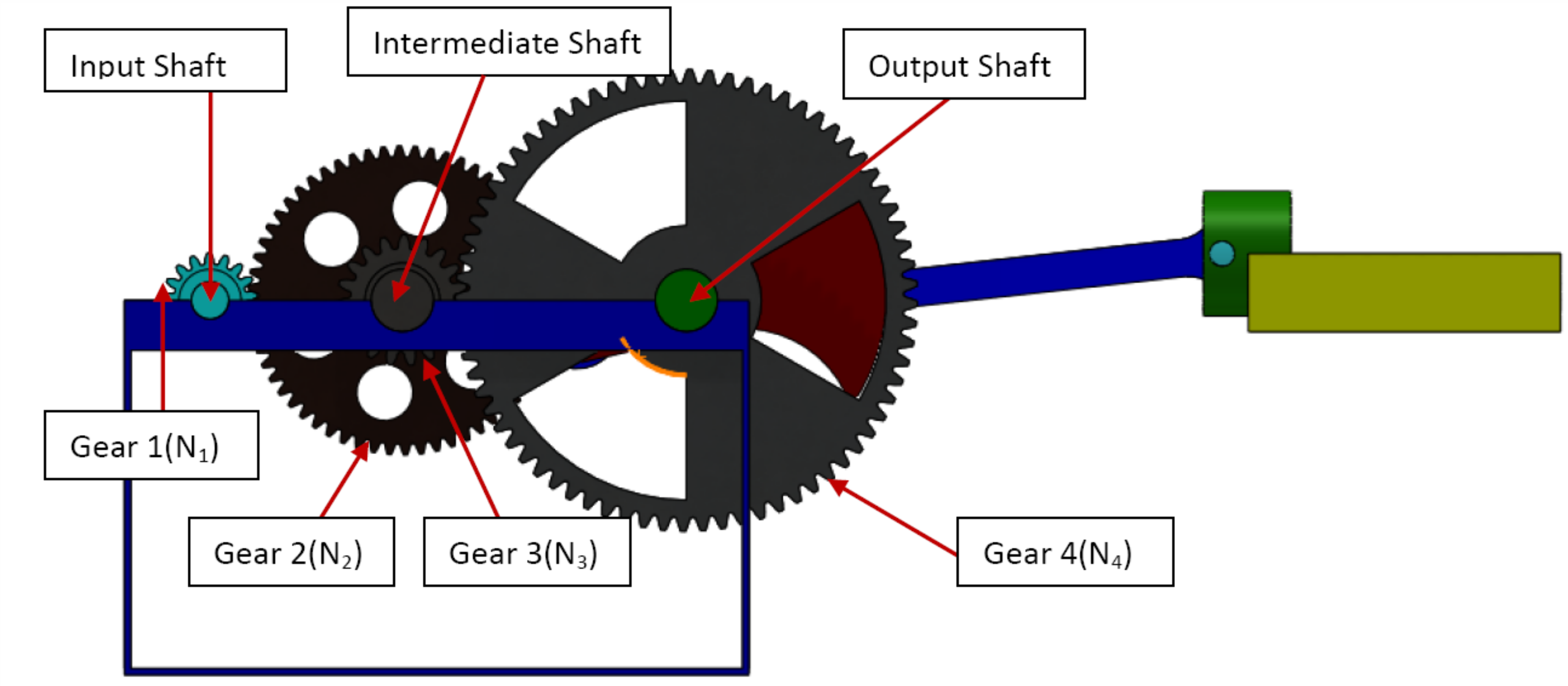
Crank Slider Mechanism Assembly I



Design goal:

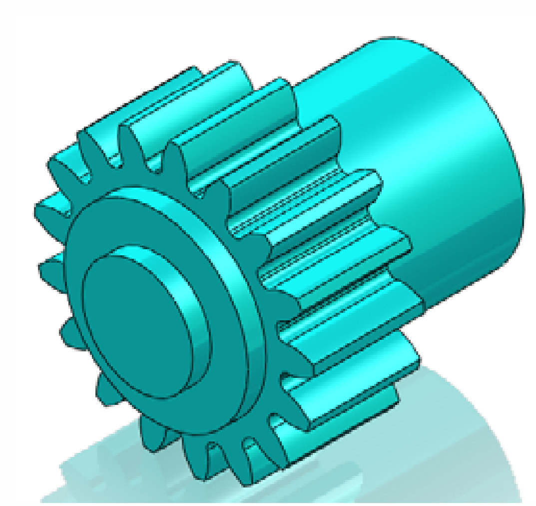
input power: P1=22kW;
input angular velocity:
n1=1500 rpm;
gear ratio: i= 13.375;

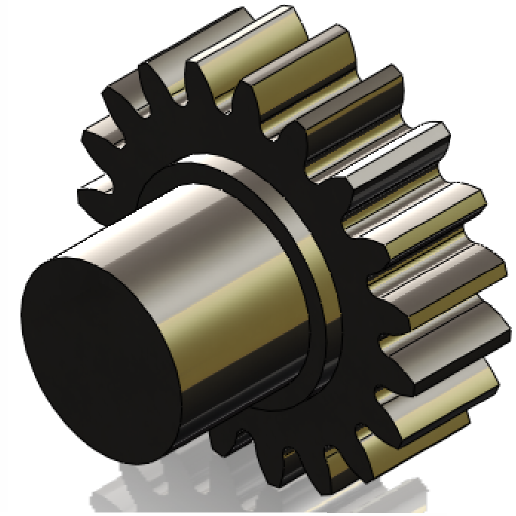
Crank Slider Mechanism Assembly II

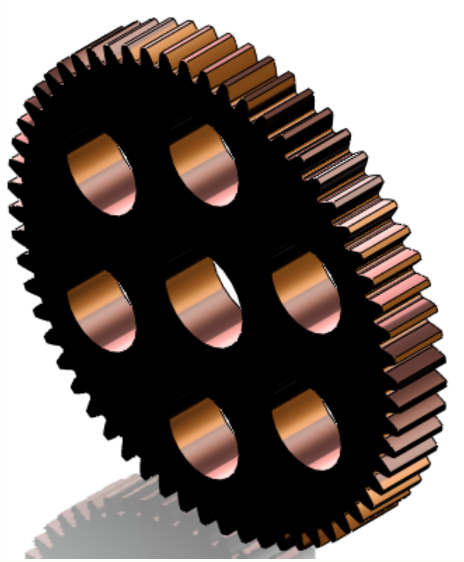


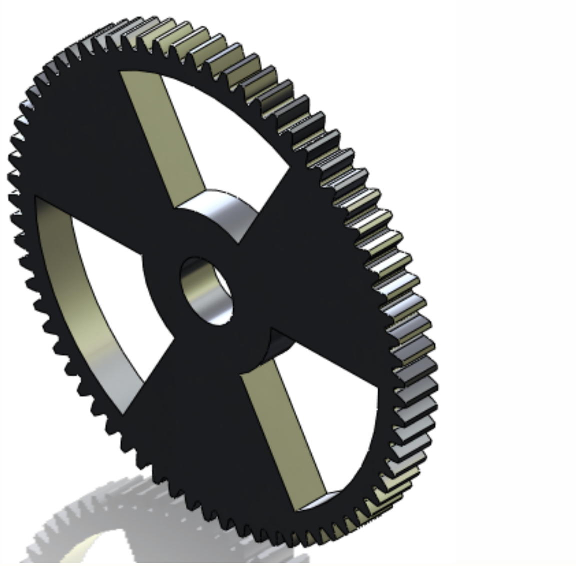
Number of teeth: N1=17, N2=60, N3=19, N4=72
Gear Modules: m1 = 4, m2 =5

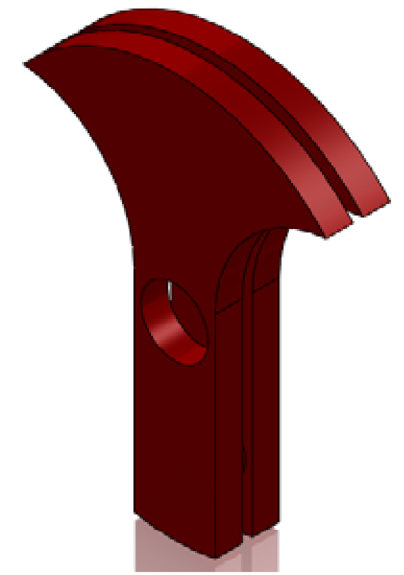
Crank Slider Mechanism Components



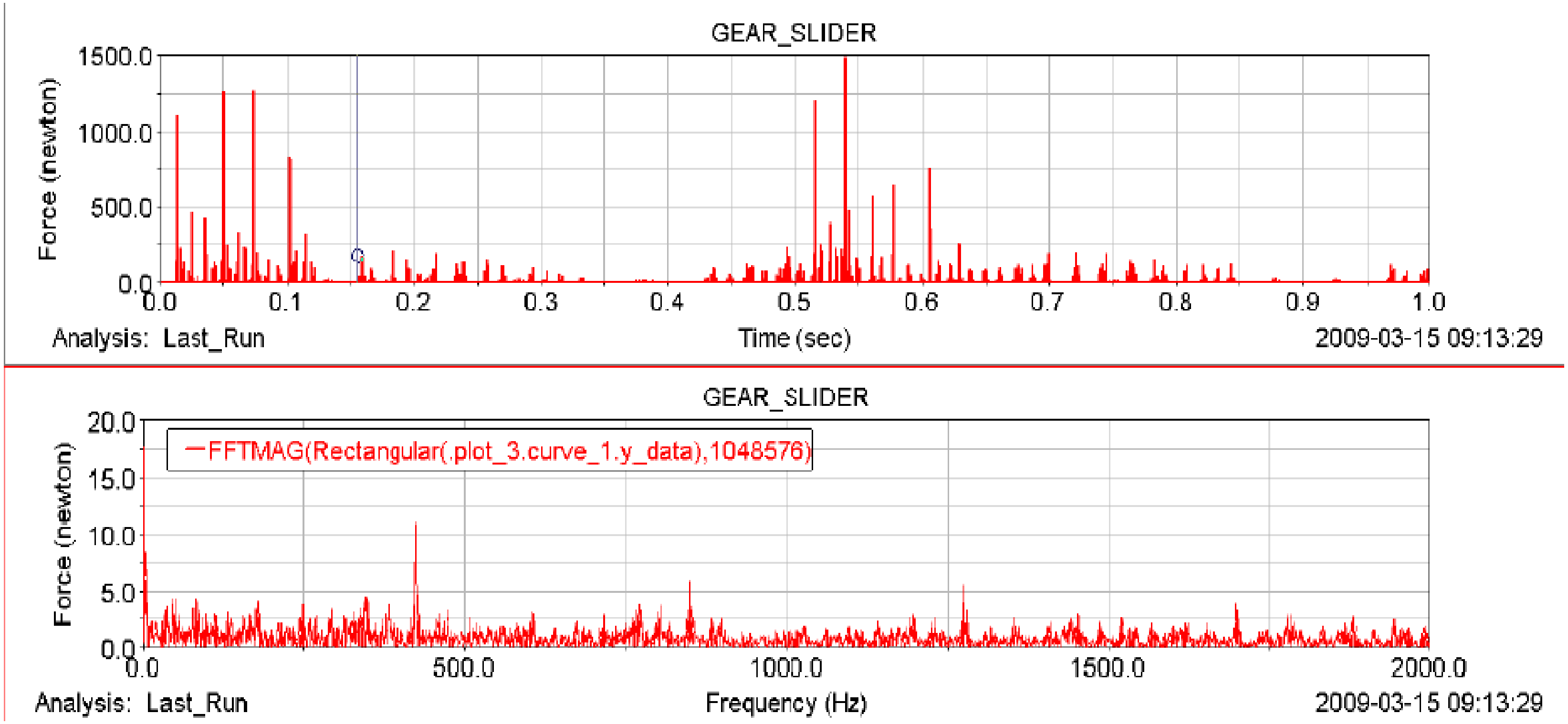






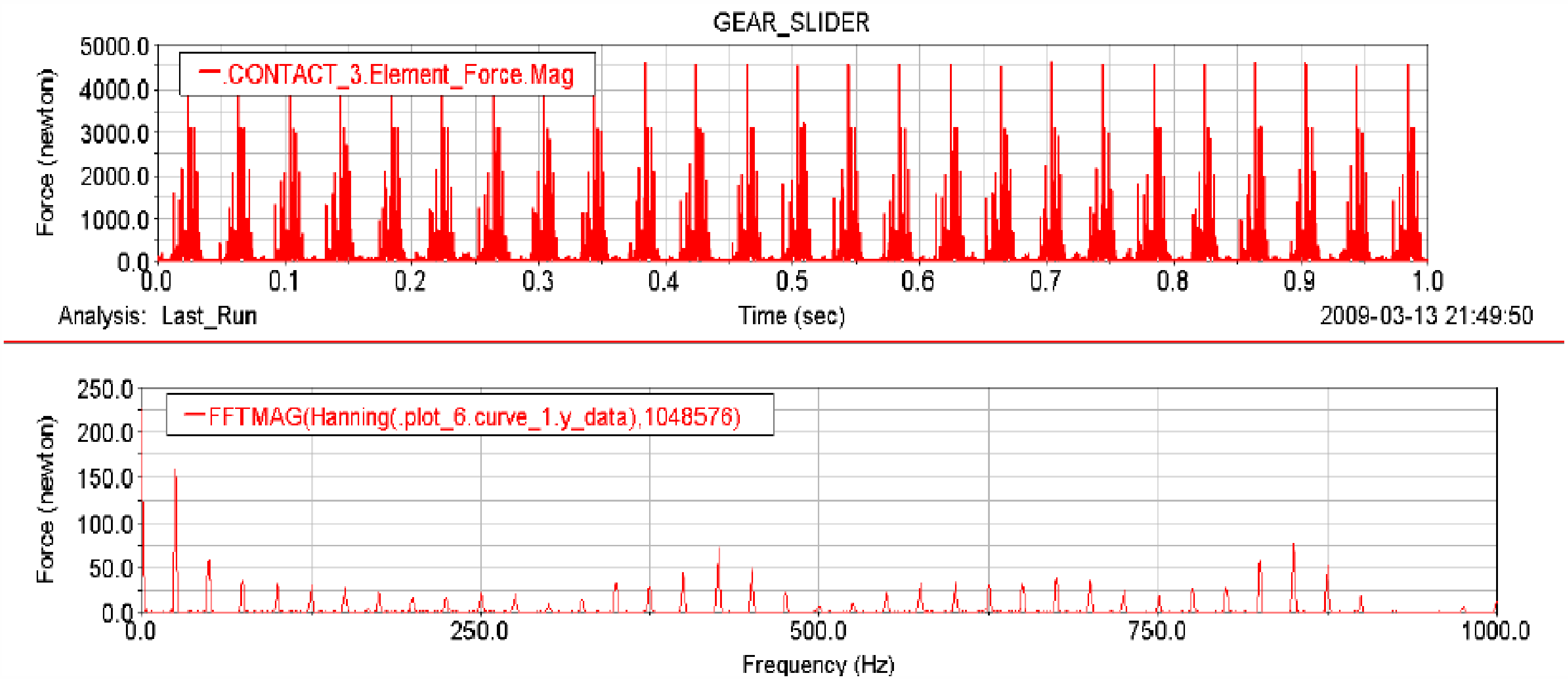


ADAMS Simulation Result I



Time base and FFT plots of the contact forces in gear pair 1-2 for a healthy crank-slider mechanism

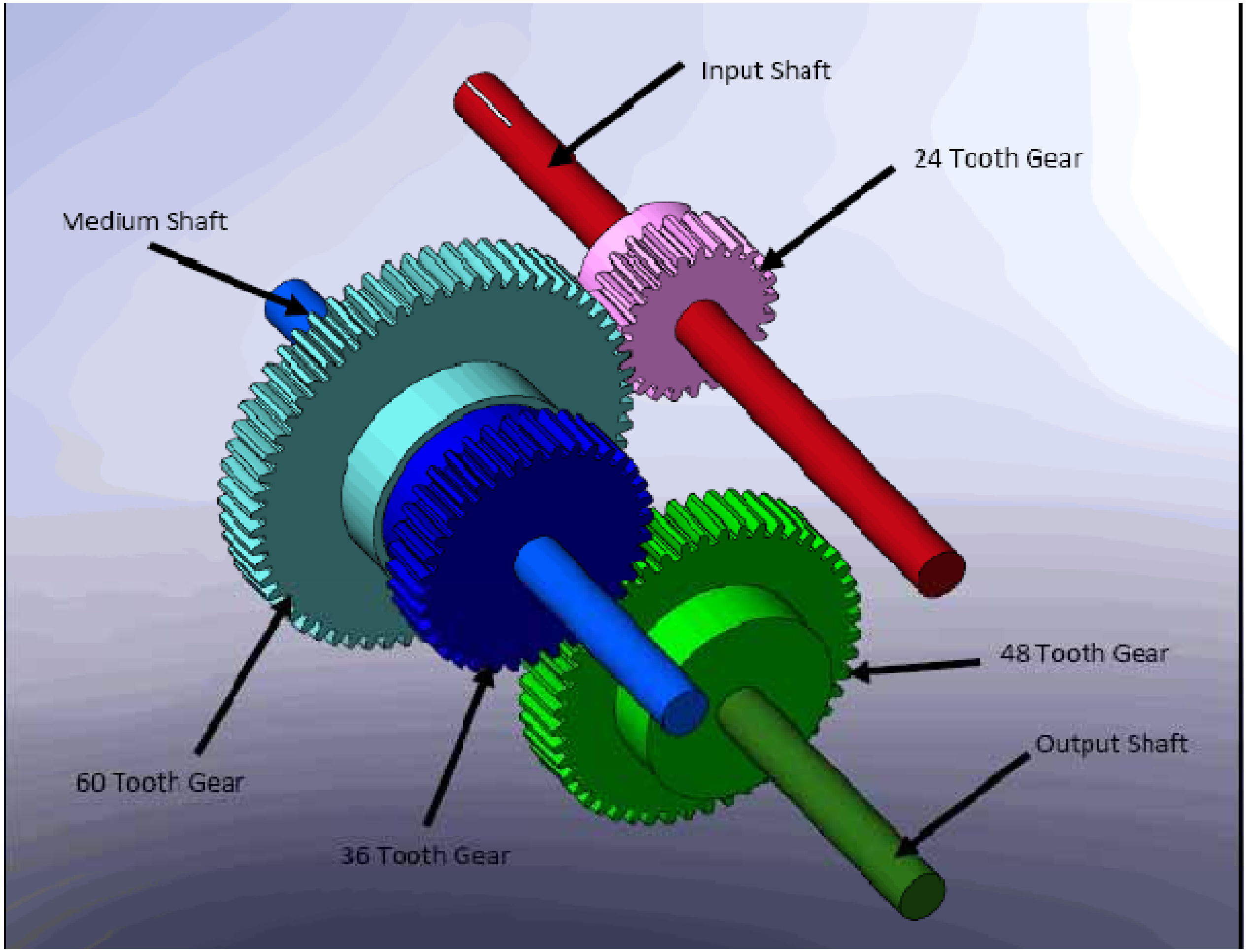
ADAMS Simulation Result II



Time base and FFT plots of the contact forces in gear pair 1-2 for a crank-slider mechanism with a damaged pinion tooth.

Practical Gear Box Design

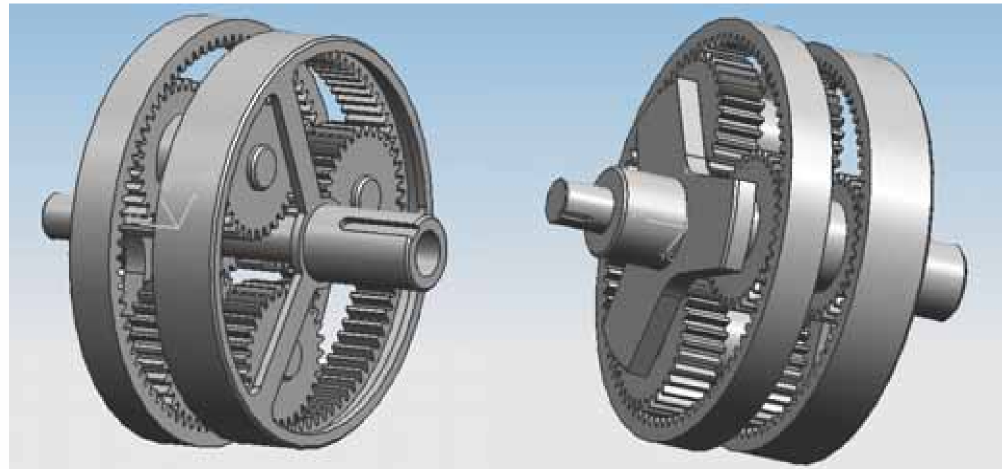
This is a practical gear train in vibration Lab.
Design parameters:
Face width: ¾ in;
Diametral Pitch: 12 teeth/inch;
Pressure Angle: 14.5°

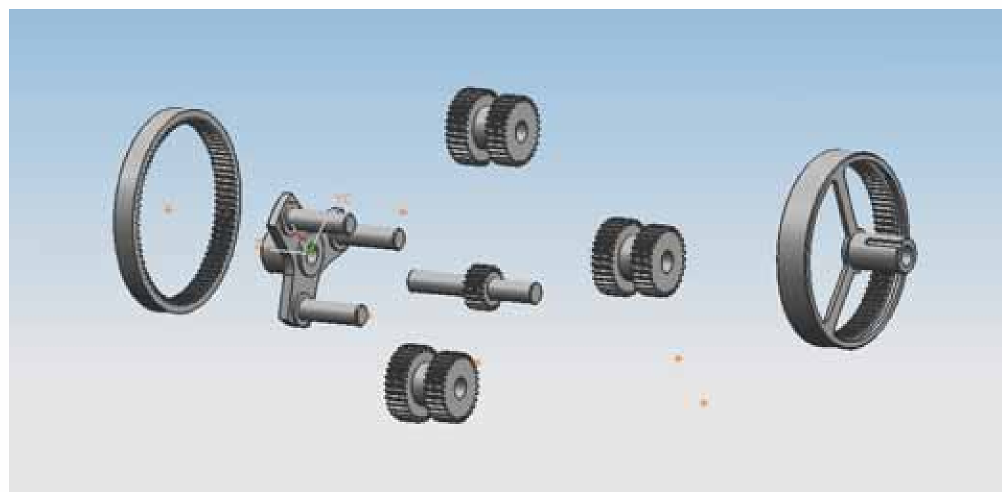


Planetary Gear Transmission I

Design Goal:

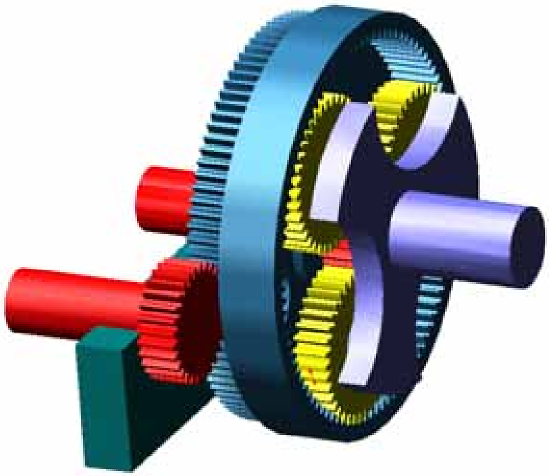
input power P1=22kW;
input angular velocity;
n1=1500 rpm;
gear ratio: *i*= 99;

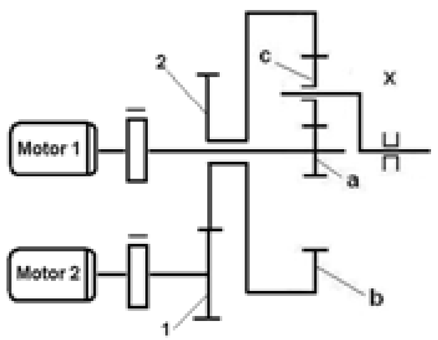


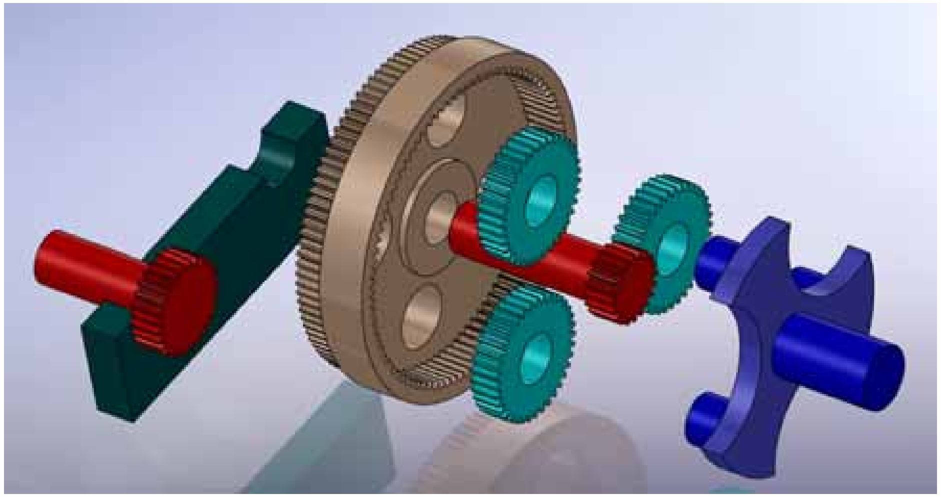


Differential Driving System

Design Requirement:
P1=7.5kW; n1=980 rpm for motor 1;
P1=5.5kW; n1=750 rpm for motor 2;
z1=28, z2=98, za=20, zc=37, zb=94;





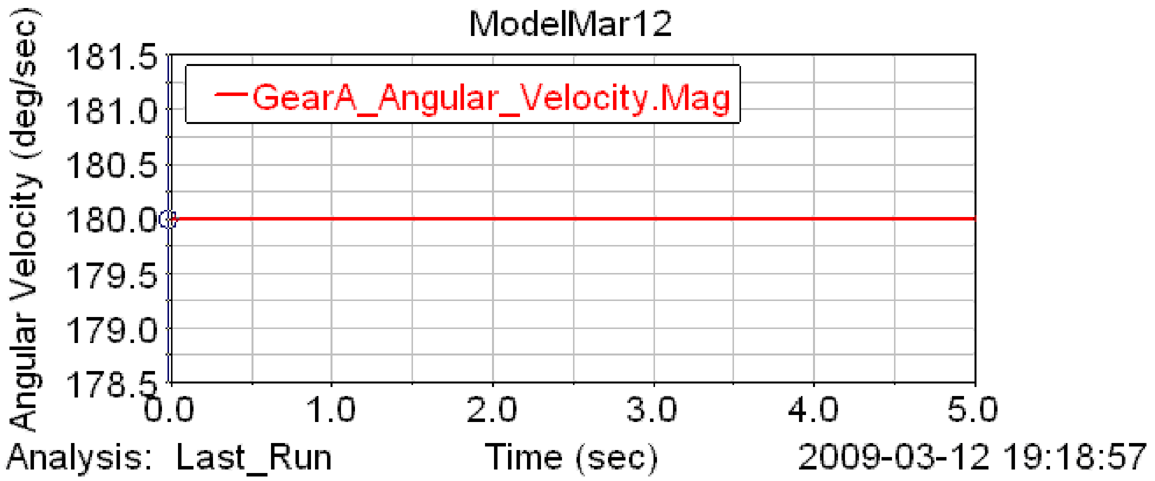


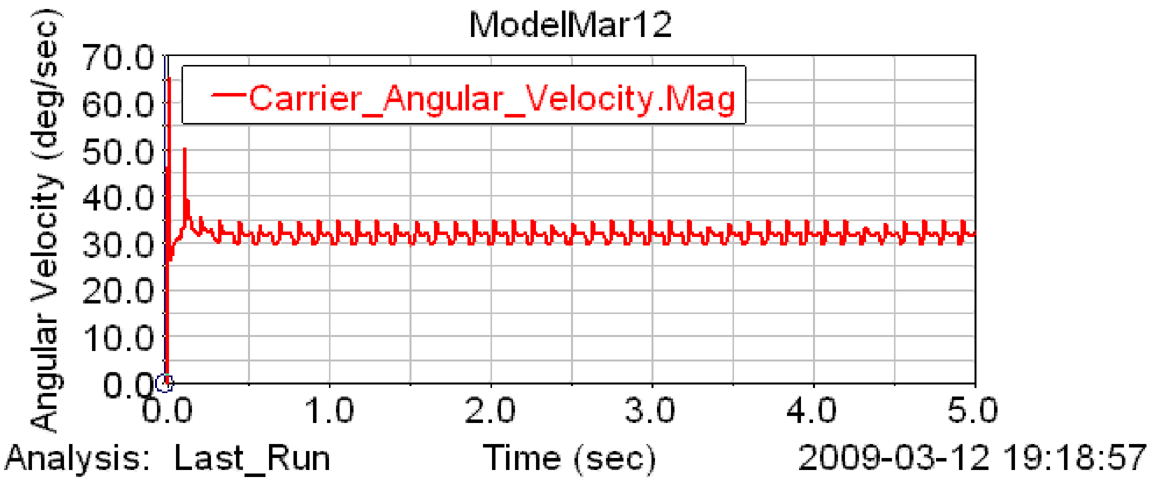
ADAMS Verification I

Case 1. Sun gear a operates at 180°/sec; Theoretical carrier output is

$$n_x = \frac{n_1}{i_{ax}^b} = \frac{180}{5.7} = 31.57^\circ/\text{sec}$$

ADAMS carrier output: 31.52º/sec





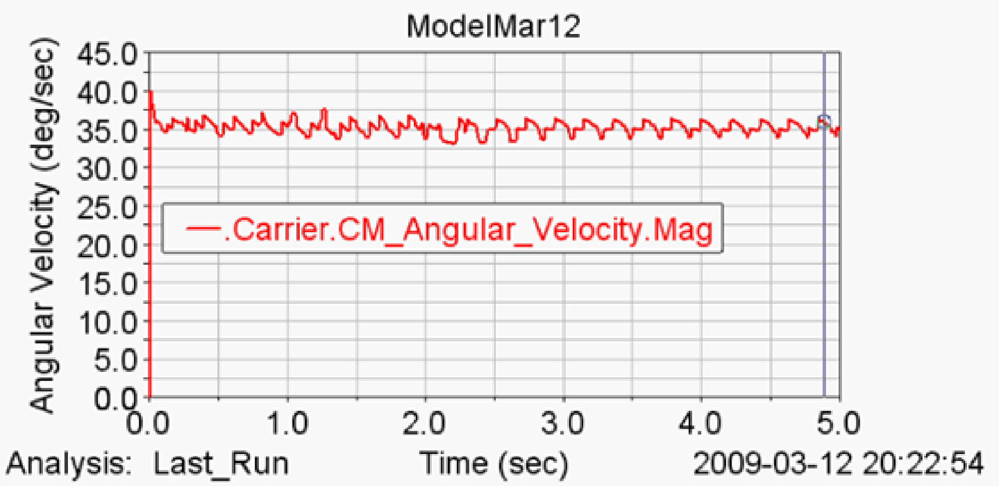
ADAMS Verification II

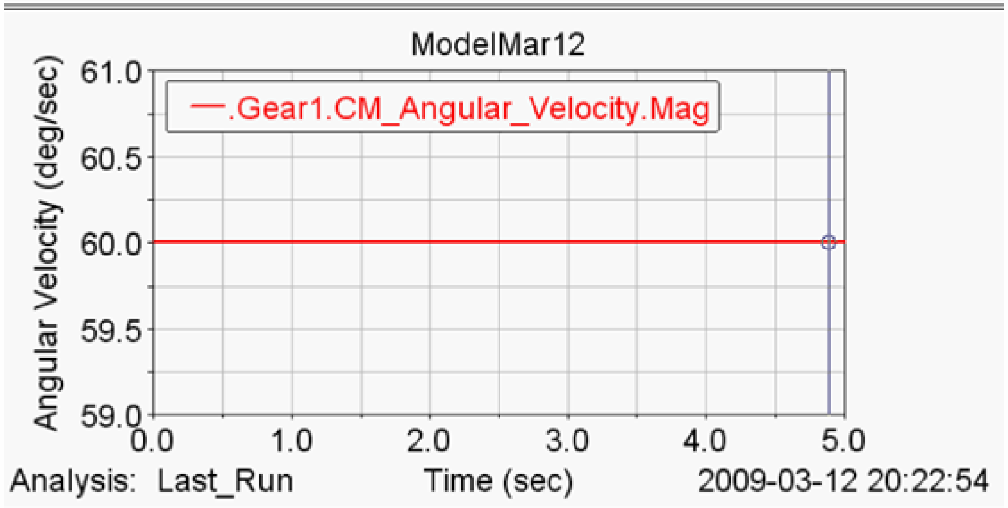
Case II. Sun gear a operates at 120º/sec; Gear 1 operates at 60º/sec; The motors run in opposite direction. Theoretical carrier output is

$$n_x = \frac{n_a}{i_{ax}^b} + \frac{1}{i_{bx}^a}\frac{n_2}{i_1}$$

$$= \frac{120}{5.7} + \frac{60}{1.213*3.5} = 35.18^\circ/\sec$$

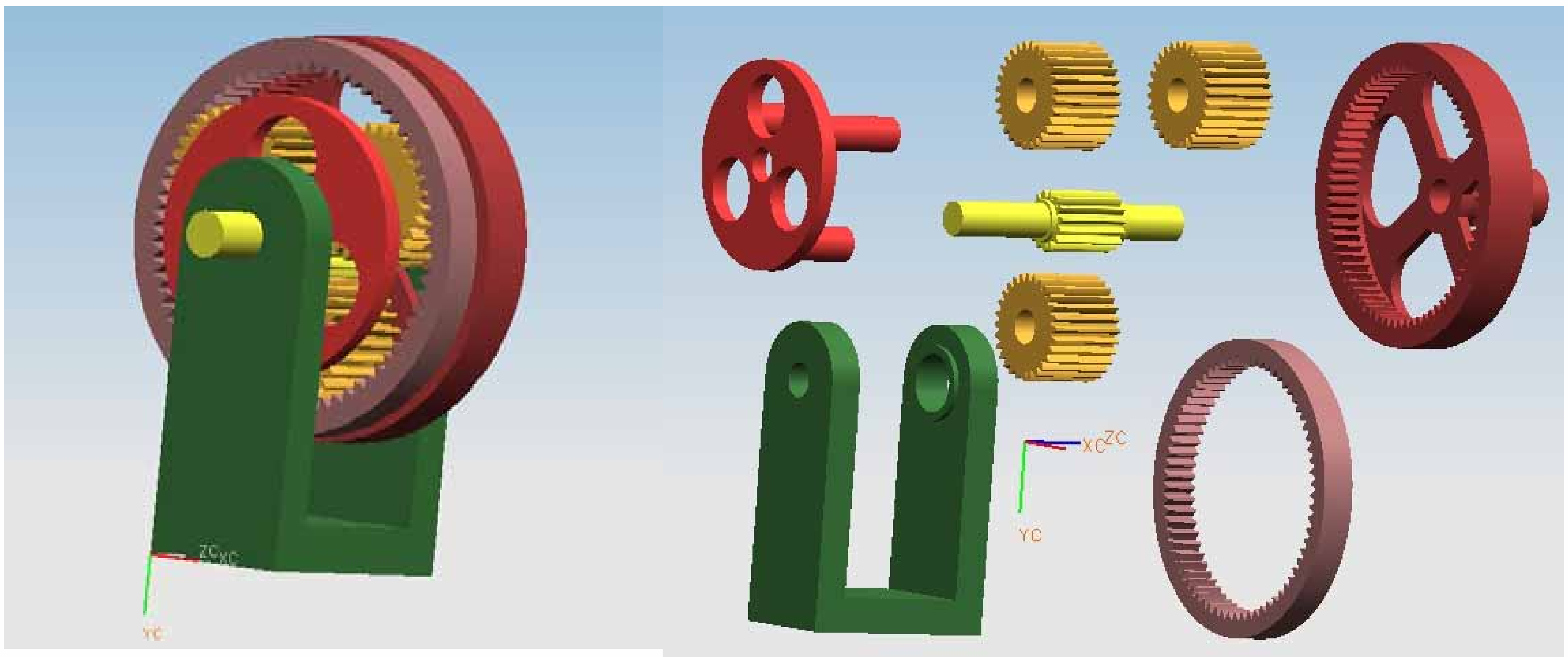
ADAMS carrier output: 35.16º/sec





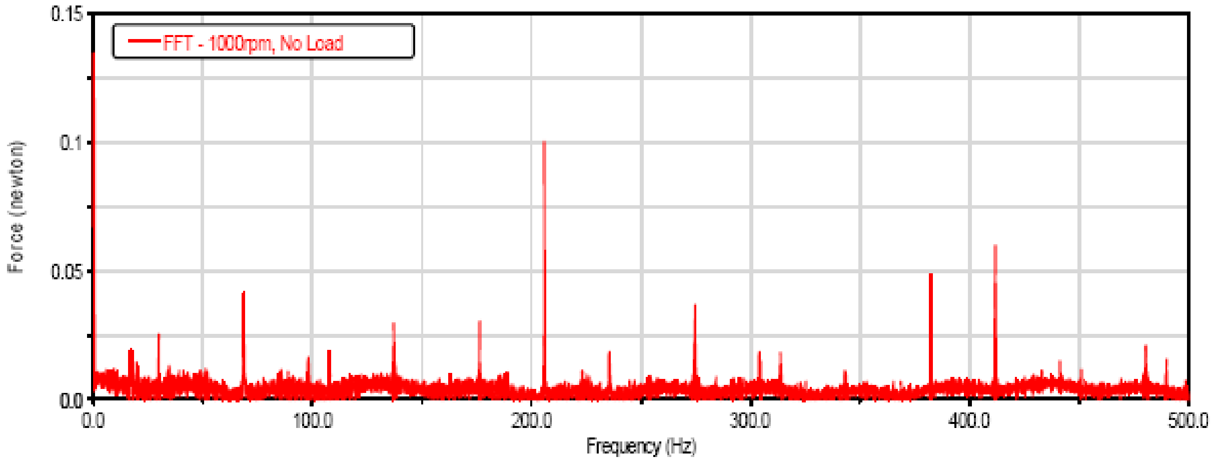
Planetary Gear Transmission II

Non-standard gear train design:
Design parameters: P1=22kW; n1=1500 rpm; Gear ratio: *i*=134
Number of sun gear teeth: 15; Number of planet gears: 3



ADAMS Simulation Results

Known Frequencies	*Hz*
GMF	205.9
Input Shaft	16.71
Carrier	2.974
Planets	4.370
Output Shaft	0.1244



The FFT of the force on the input shaft joint yielded many peaks when the gearbox was very lightly loaded. Note: 29.4838 Hz = GMF/7; 274.5552 Hz = 4GMF/3; 411.8118 Hz = 2GMF, etc…

Conclusions and Acknowledgement

Mechanical Engineering
CAL POLY

- ADAMS software can be used effectively to facilitate mechanical design with a short learning curve.
- ADAMS is being used to help our program meet ABET accreditation requirements for student skills.
- The introduction of ADAMS into the course allowed students to experience a culminating design experience that combined previous coursework.
- ADAMS can predict the fault patterns of a gear train and may obviate some costs of field testing.
- The authors have found the ADAMS software to be a useful teaching and research tool.
- The authors gratefully acknowledge the contributions from ME518 students.

Contact Details :

- For further information please contact

Xi Wu

Department of Mechanical Engineering

California Polytechnic State University

San Luis Obispo, CA93407-0358

Telephone Number: (805) 756-5214
Email Address: xwu@calpoly.edu