Connect to All

RECURDYN

Particleworks CFD DEM FEA MBD MFBD Control MBS-FE Coupling FMI CoLink Simulink SimulationX AMESim Simplorer EDEM

RecurDyn V9R3: Toolkits, Controls, and Co-simulation Interfaces

Nelson Woo

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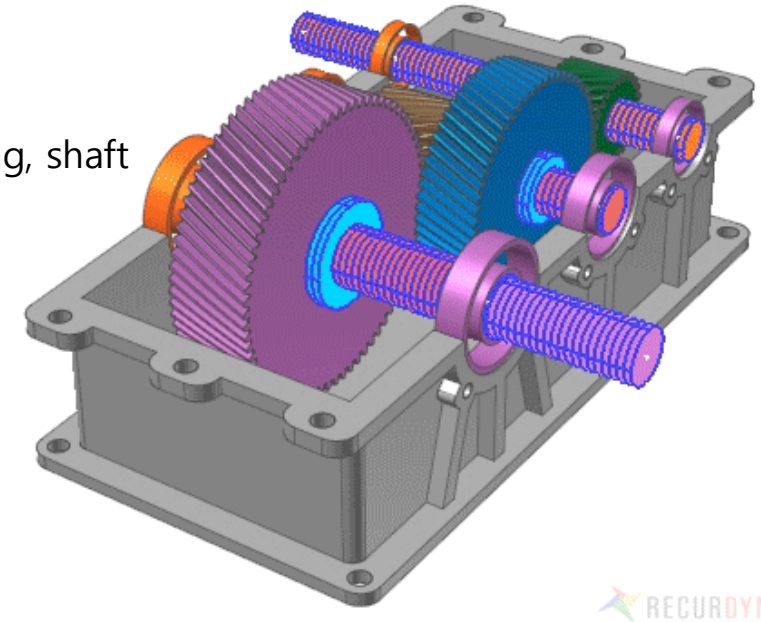
RecurDyn/DriveTrain

1. Overview of RecurDyn/DriveTrain

1. Target Uses

1) Drivetrain
   A. Gearbox modeling composed of gear, bearing, shaft
      a. such as transmission, speed reducer
2) Electrified Powertrain
   A. Drivetrain for motor-driven system



2. Features

1) KISSsoft Interface

A. Embedded KISSsoft GUI/Solver
   a. Gear modeling and bearing modeling
   b. Gear Analytic Contact
   c. Gear analysis using embedded KISSsoft GUI is supported

2) Dynamic Analysis of Drivetrain

A. KISSsoft (Static Analysis) + RecurDyn (Dynamic Analysis)
B. Understanding the behavior of the drivetrain

3) MFBD (Multi-Flexible Body Dynamics)

A. Shafts modeled as flexible using beam elements
B. Flexible bodies can be attached (such as housing)
C. Eventually, RecurDyn/Durability, RecurDyn/Acoustics can be used

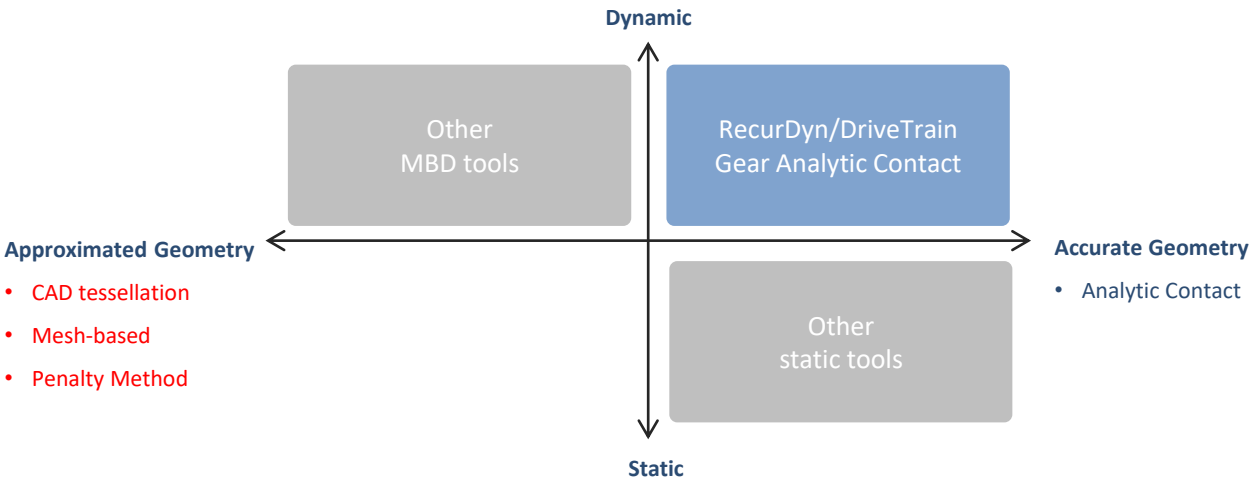
4) NVH analysis

A. Order tracking analysis using Campbell diagram

2. 6 advantages of RecurDyn/DriveTrain (1)

1
Accurate Gear Analytic Contact

- Since Transmission Error is a very small value (μm), accurate contact calculation is crucial.
- FunctionBay provides accurate Gear Analytic Contact through technical cooperation with Gleason/KISSsoft
- KISSsoft is a program for sizing, optimizing and recalculating designs for machine componen ts such as gears, shafts and bearings, screws, springs, joining elements and belts.
- Advantages of Gear Analytic Contact of RecurDyn/DriveTrain
  - Theory-based contact calculation considers detailed gear design parameters
  - Considers deformation of gear teeth
  - Considers tolerance of gear teeth
  - Contact available in dynamic simulation



2. 6 advantages of RecurDyn/DriveTrain (2)

2
Easy modeling with specialized UI

- Easy drivetrain modeling (gears/bearings/shafts) through specialized dialog
- Supports detailed gear design through built-in KISSsoft UI

CylindricalGear [Current Unit : N/kg/mm/s/deg]

General | Cylindrical Gear

Assembly Reference Point (Gear1): -100., 0, 0
Gear Normal Direction: 0, 1., 0
Assembly Reference Direction: 1., 0, 0 [Pt]
Use KISSsoft Z12 Module Files [Z12 Module Files]

Gear Geometry
Normal Module: 6.
Gear Type: Spur Gear
Pressure Angle at Normal Section: 20.
Helix Angle at Reference Circle: 0.

Gear	No. of Teeth	Face Width	Profile Shift Coefficient	Details	Profile	Tolerance	Modification	Material
1	25	44.	0.2485	...	Factors ...	...	...	18CrNiMo7-6, Case...
2	76	44.	-0.2485	...	Factors ...	...	...	18CrNiMo7-6, Case...

Add | Delete | Insert

Gear Pair

Pair	Base Gear	Action Gear	Center Distance	Backlash	Axial Offset	Rot. Angle	Contact	Meta Model	Import	Export	KISSsoft UI
1	1	2	303. Calc.	0.346647... Calc.	0.	0.	...	...	...	...	...

Add | Delete | Insert

Gear Force Type: Inactivate
Each Rendering: Automatic
Force Display: Inactivate

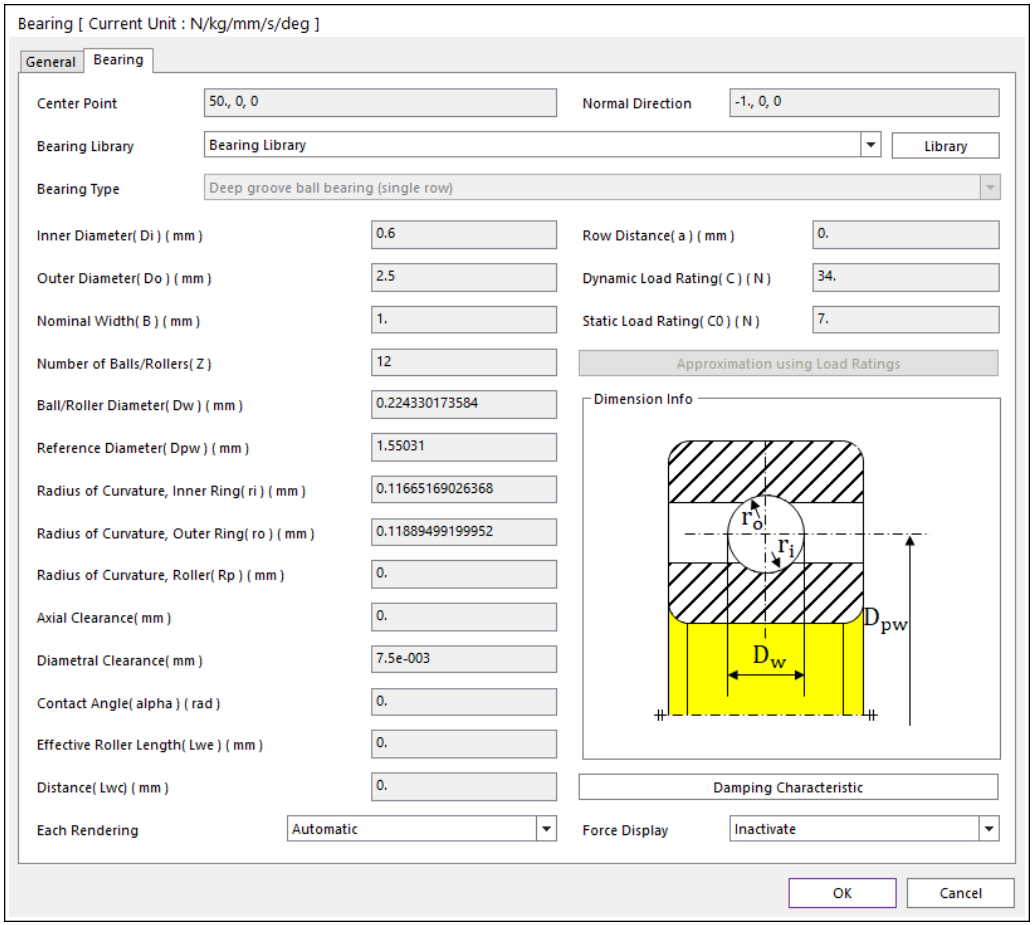
OK | Cancel

KISSsoft Gear Modeler

2. 6 advantages of RecurDyn/DriveTrain (2)

2
Easy modeling with specialized UI

- Easy drivetrain modeling (gears/bearings/shafts) through specialized dialog
- Supports detailed gear design through built-in KISSsoft UI



KISSsoft Bearing Modeler

2. 6 advantages of RecurDyn/DriveTrain (2)

2
Easy modeling with specialized UI

- Easy drivetrain modeling (gears/bearings/shafts) through specialized dialog
- Supports detailed gear design through built-in KISSsoft UI

Shaft [Current Unit : N/kg/mm/s/deg]

General | Shaft

Sections

No	L	Ro	Ri	Ref. Element Size	Property	Material
1	100.	25	10	50	Tube	...
2	150	50	10	50	Tube	...
3	100	50	0	50	Rod	...
4	100	25	0	50	Rod	...
5	50	200	0	50	Rod	...

Add | Insert | Delete | Dimension Info. | FDR

☑ Use CoAxial Shaft for End Section

No	L	Ro	Ri	Ref. Element Size	Radius	Angle	Property	Material	FDR
1	50	30	0	50	150	0	Rod	...	0 ...
2	50	30	0	50	150	120	Rod	...	0 ...
3	50	30	0	50	150	240	Rod	...	0 ...

Add | Insert | Delete | Dimension Info.

Material Update for All

Import | Export

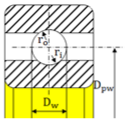
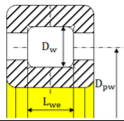
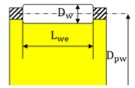
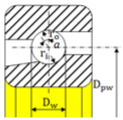
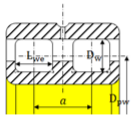
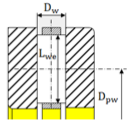
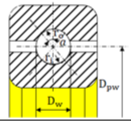
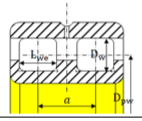
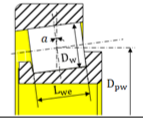
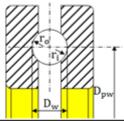
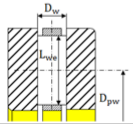
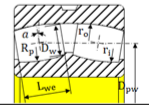
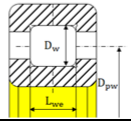
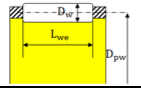
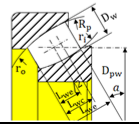
OK | Cancel

KISSsoft Shaft Modeler

2. 6 advantages of RecurDyn/DriveTrain (2)

3
Various bearing libraries

- 15 different types of bearings (ISO/TS 16281)
- Provides bearing database of 8 global brands
- Bearing creation with tens of thousands of libraries

Bearing Types	Bearing Section View	Bearing Types	Bearing Section View	Bearing Types	Bearing Section View
Deep groove ball bearing (Single row)		Cylindrical roller bearing (Single row, Full complement)		Needle cage	
Angular contact ball bearing (Single row)		Cylindrical roller bearing (Double row)		Thrust needle cage	
Four point bearing		Cylindrical roller bearing (Double row, Full complement)		Tapered roller bearing (Single row)	
Deep groove thrust ball bearing (One sided)		Axial cylindrical roller bearing		Spherical roller bearing	
Cylindrical roller bearing (Single row)		Needle roller bearing (with/without internal ring)		Axial spherical roller bearing	

2. 6 advantages of RecurDyn/DriveTrain (3)

4
Entire system modeling

- Simulates behavior of entire system, not a component
- Understands the interaction between each element and improves it
- Assemblies including housing can be modeled as flexible bodies using MFBD technology

5
Transient Analysis using Dynamic Solver

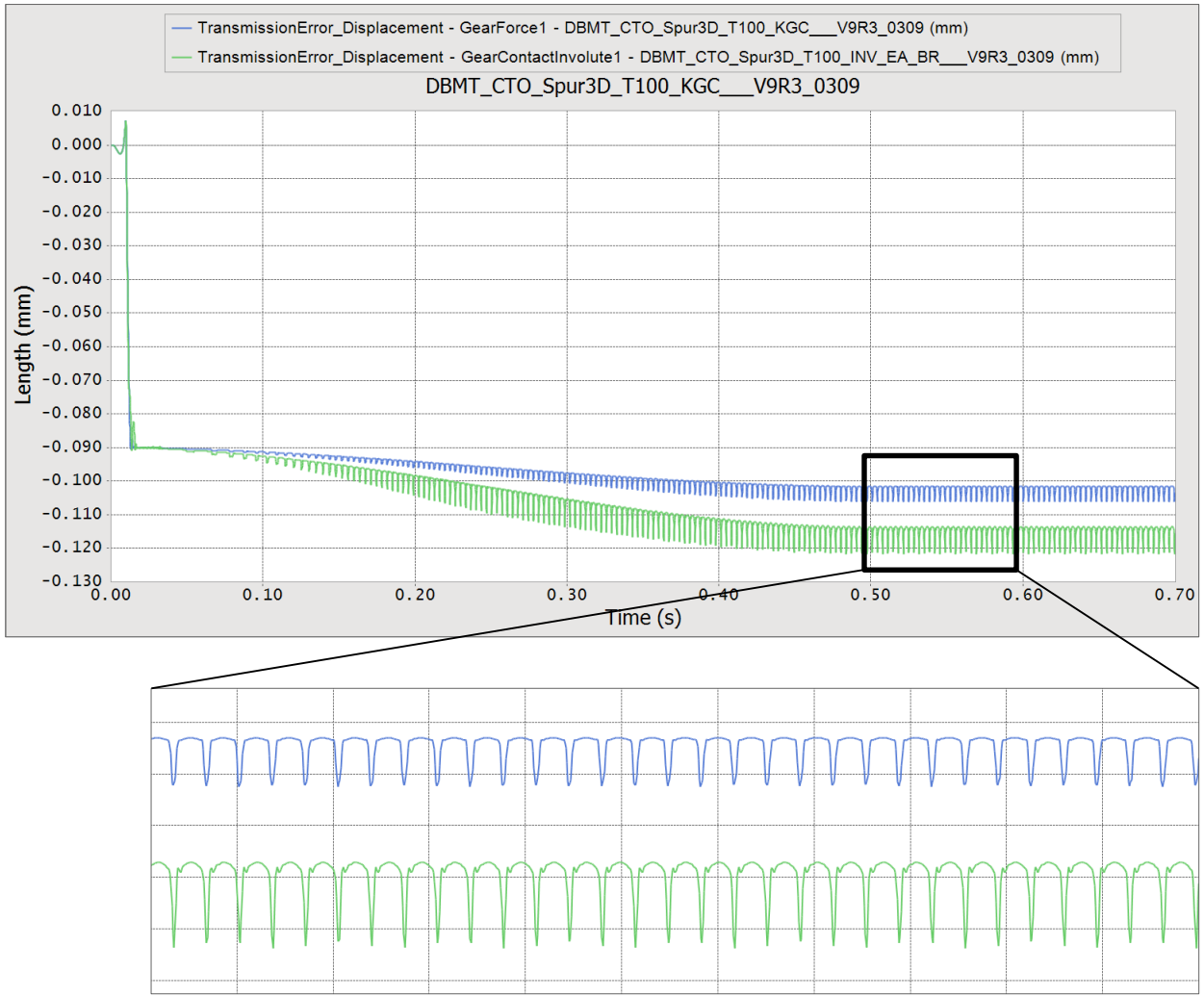
- The most relevant transmission error measurement for noise and vibration predictions are the dynamic type. [1)]
  - The Dynamic Transmission Error needs to be measured under the environment where gear, bearing, shaft and housing are included in model
- In particular, robust transient simulation is required for the high speed system
- Various causes of gear misalignment can be simulated:
  - Initial assembly error, shaft deformation, bearing stiffness, housing deflection

1) GEAR NOISE AND VIBRATION– A LITERATURE SURVEY, 2001, Mats Åkerblom

2. 6 advantages of RecurDyn/DriveTrain (4)

6
Various Post-processing functions

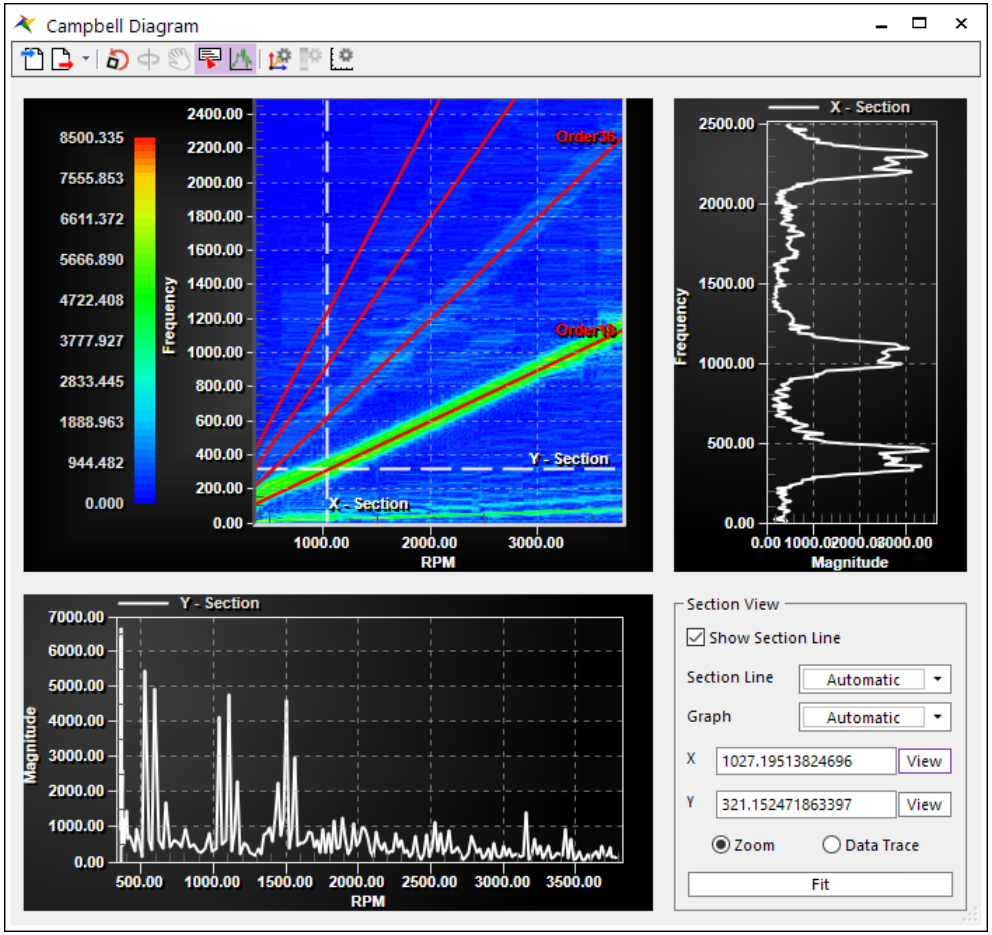
- Check the transmission errors



2. 6 advantages of RecurDyn/DriveTrain (4)

6
Various Post-processing functions

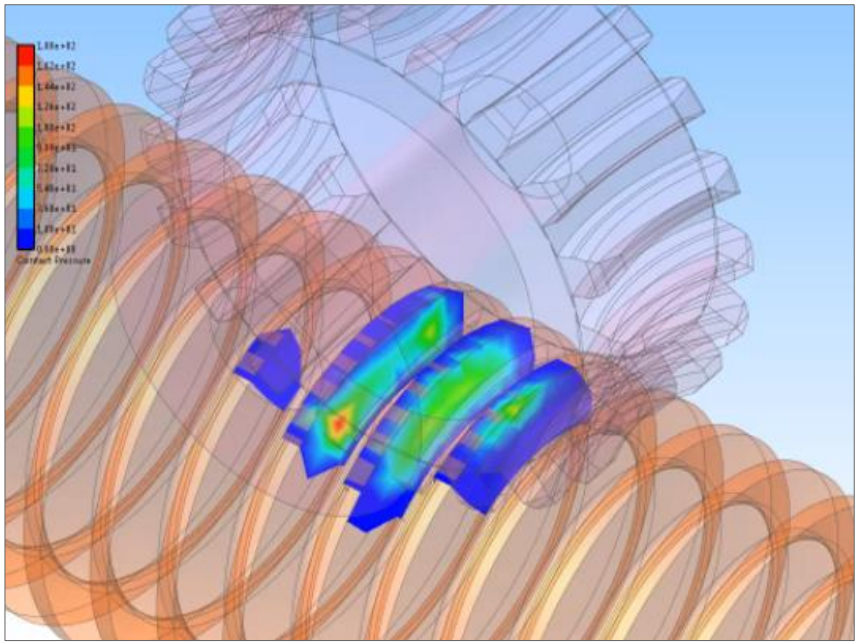
- Campbell Diagram (Order Tracking Analysis, etc.)
- Identify frequencies of major contributions to vibration/noise.
- Diagnose which part of system to address.



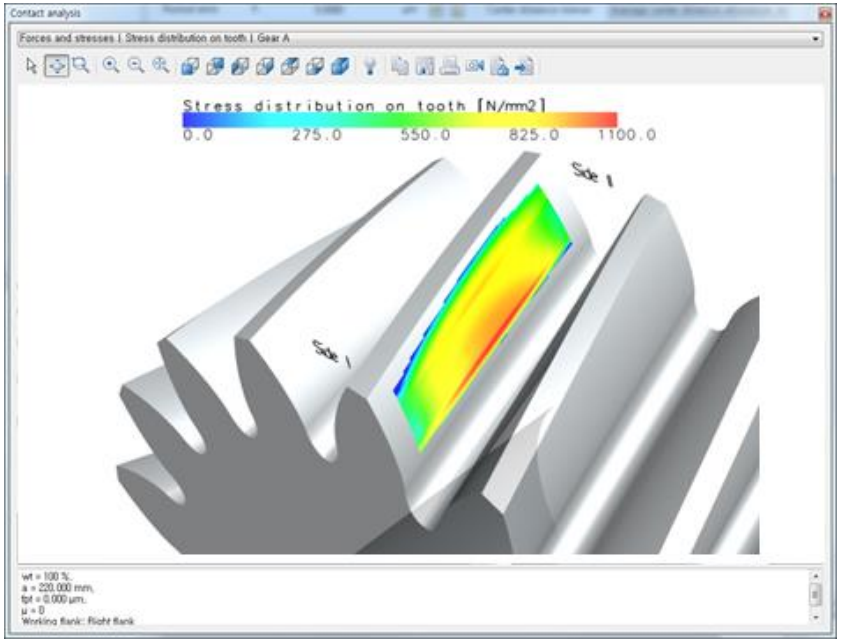
2. 6 advantages of RecurDyn/DriveTrain (4)

6
Various Post-processing functions

- Review various results such as contact pressure, tooth stress, and deformation
- Check the effect of the gear backlash
- Review the vibration of the system to analyze the rattle and whine noise
- Deformation and stress of the shaft

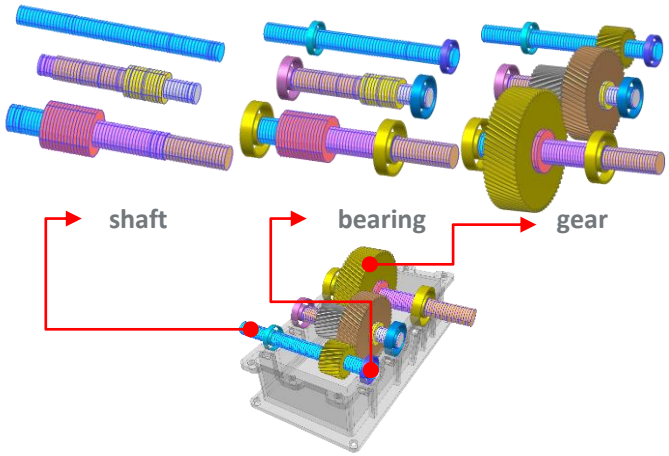


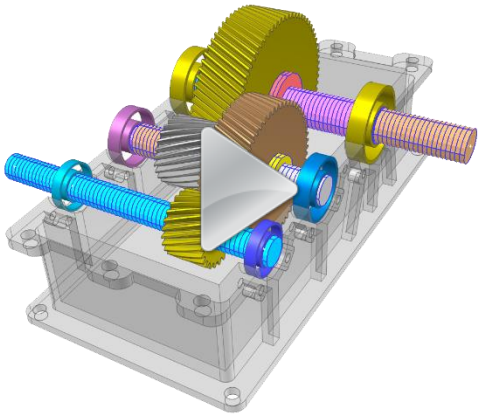
Contact Pressure

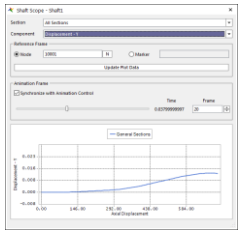


Tooth Stress

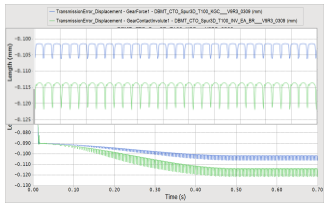
3. Simulation process using RecurDyn/DriveTrain



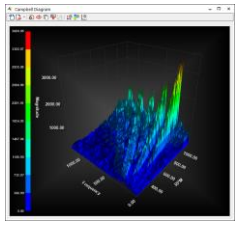




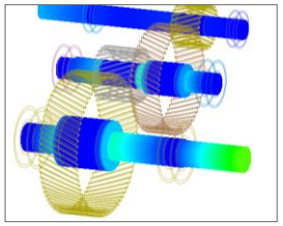
Shaft bending



Transmission Error



Campbell Diagram



Animation

1

Modeling

Build components (Shaft, Bearing, Gear) and Drivetrain system

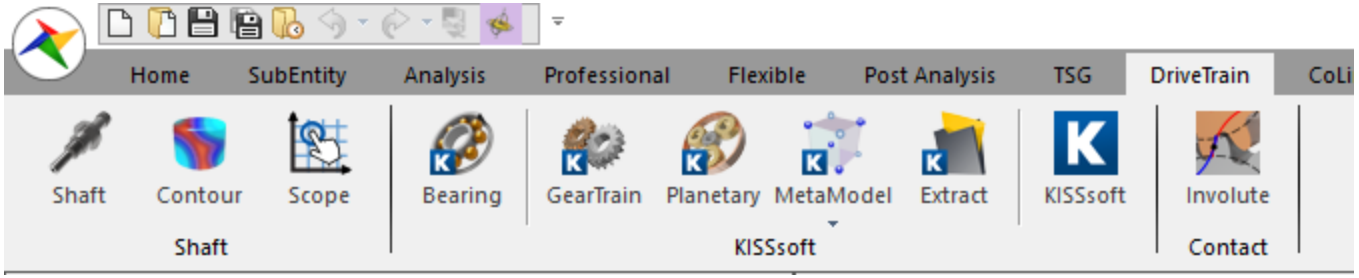
2

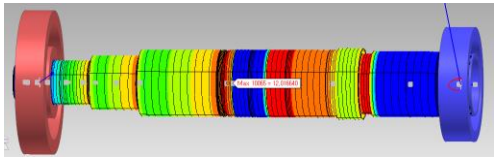
Simulation

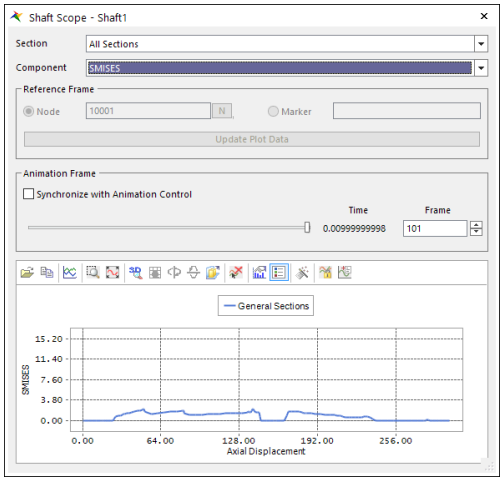
3

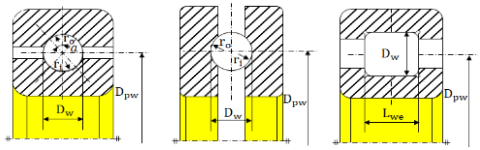
Post-processing

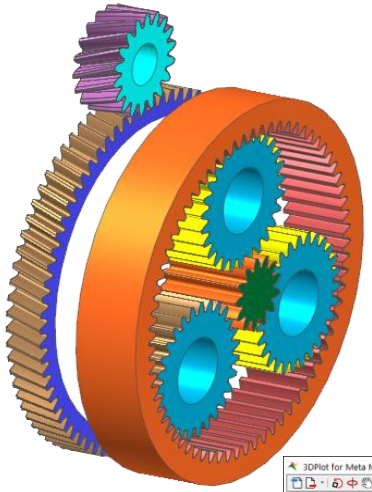
4. Main features

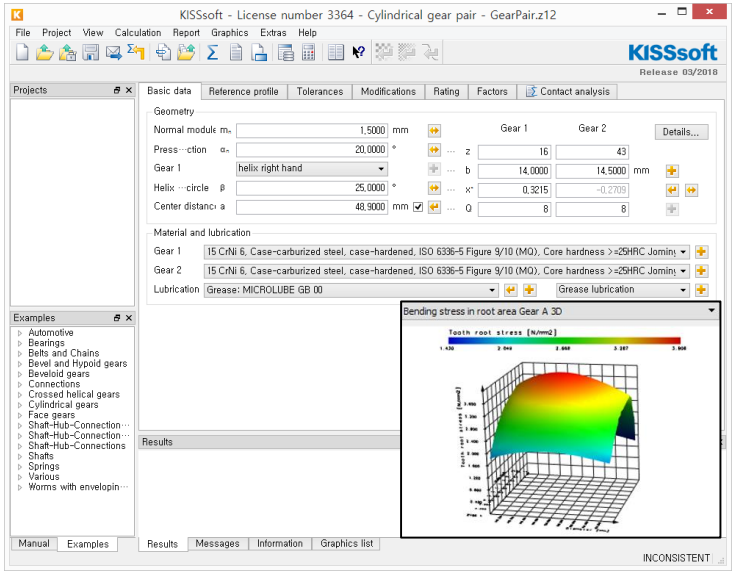


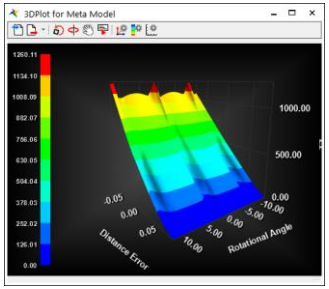


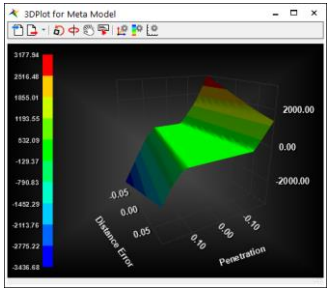


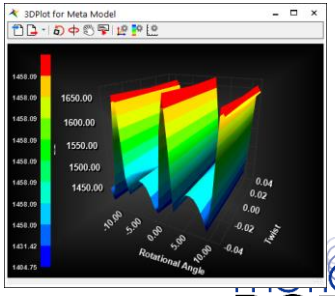






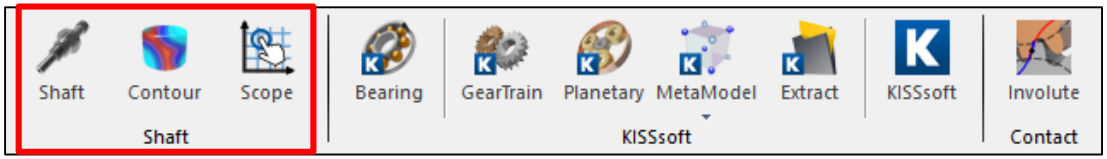


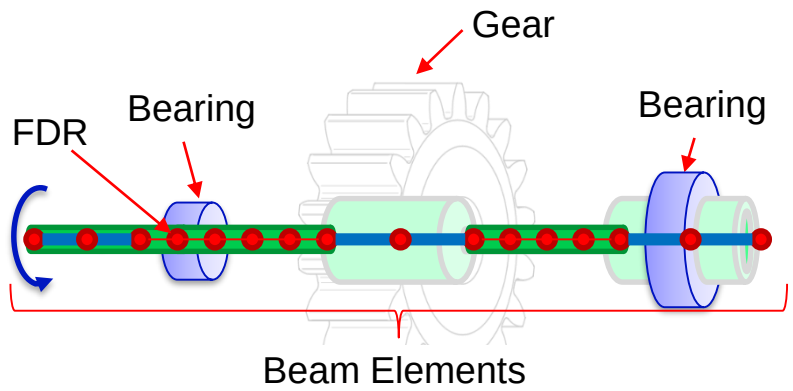


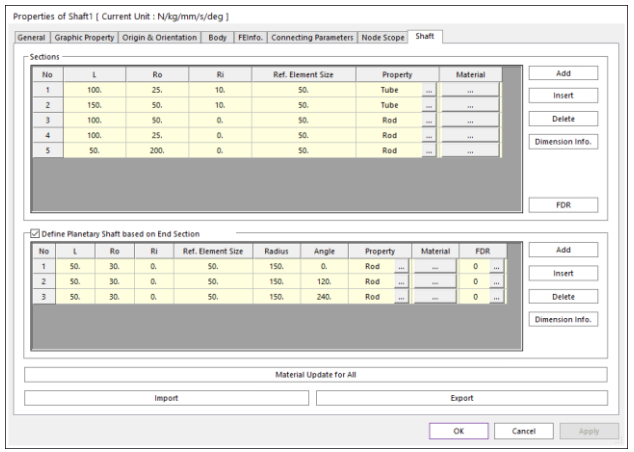


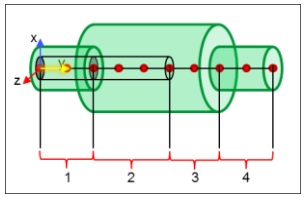
5. RecurDyn/DriveTrain – Shaft (1)

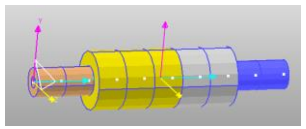
1. **Intuitive shaft modeler for easy and convenient modeling**
2. **Flexible shaft using beam to calculate the deformation and torsion**
3. **3D visualization of the beam shape based on beam properties**
4. **Automatic creation of rigid RBE (FDR) elements** (at the point where bearings and gears are engaged)

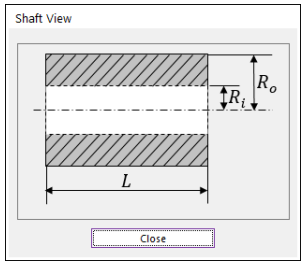






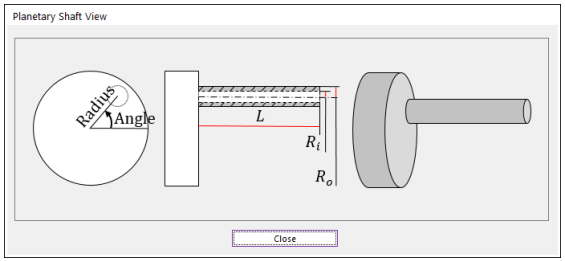


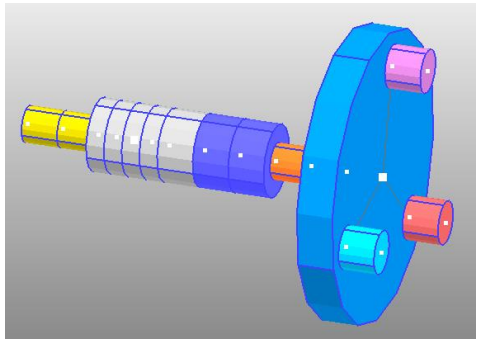


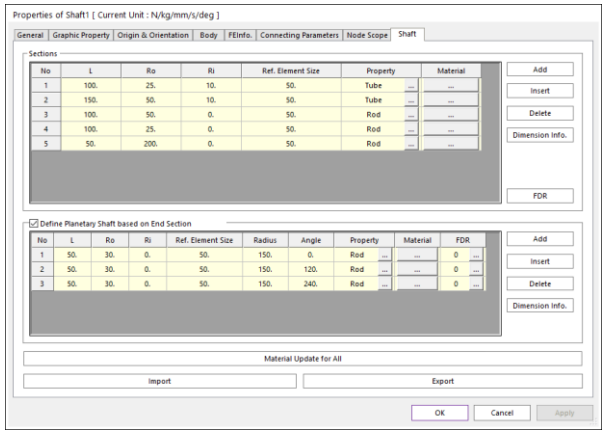


5. RecurDyn/DriveTrain - Shaft (2)

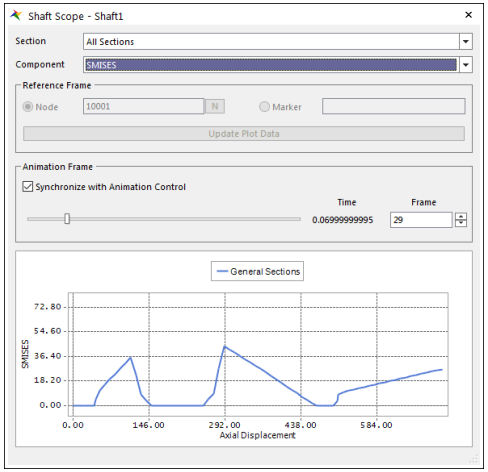
5. Support Planetary Shaft modeling for planetary gear

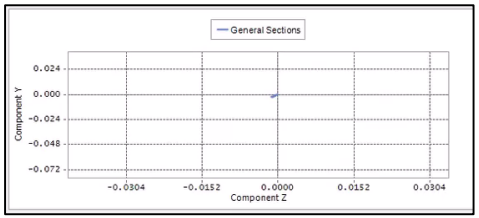


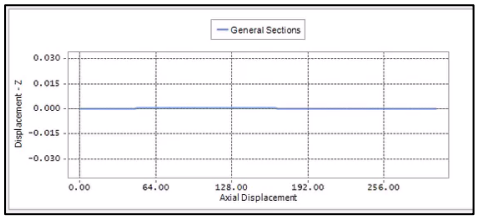


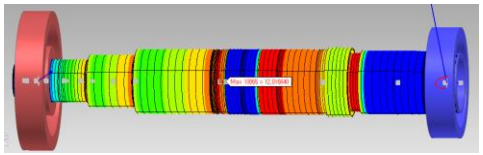


6. Supports 'shaft scope' to intuitively check the shaft deformation and other results

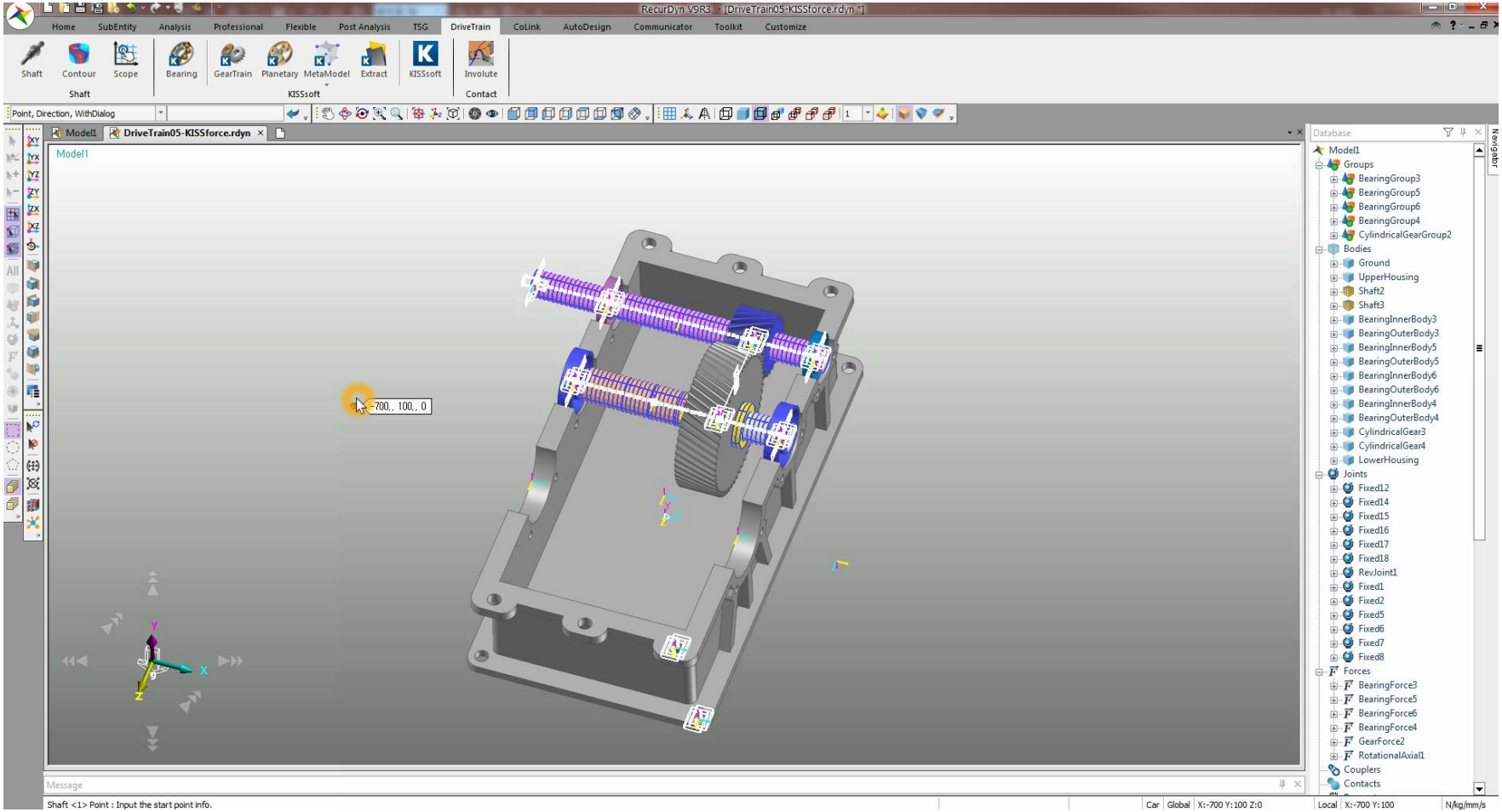




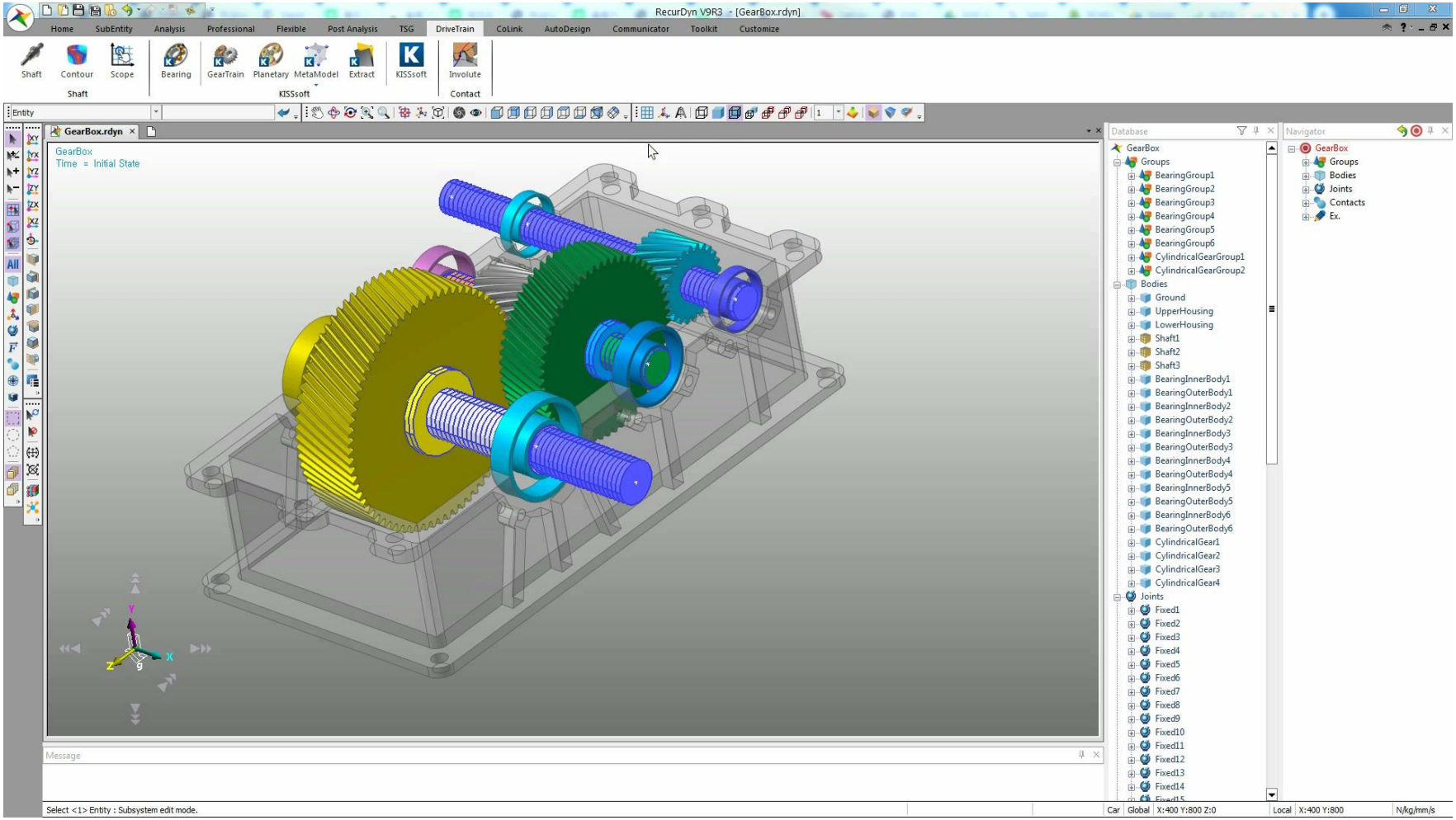




5. RecurDyn/DriveTrain - Shaft (Modeling Demo)

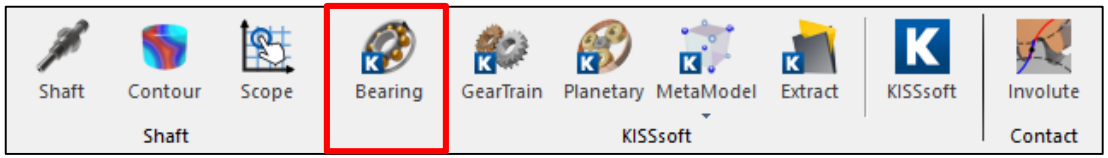


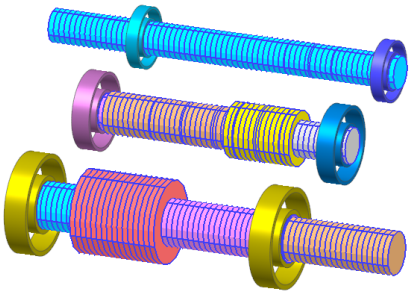
5. RecurDyn/DriveTrain – Shaft (Post-Processing Demo)

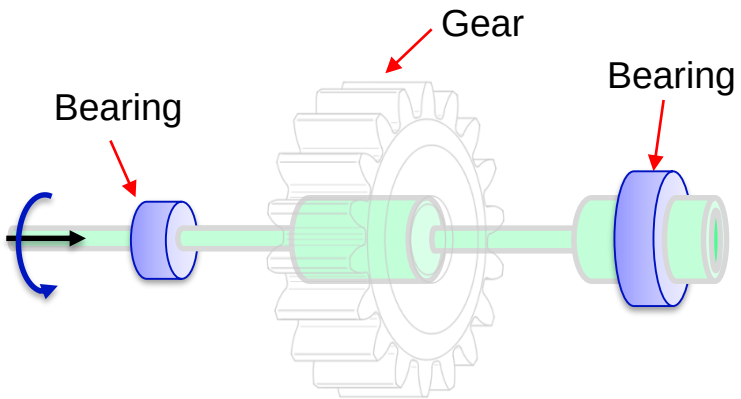


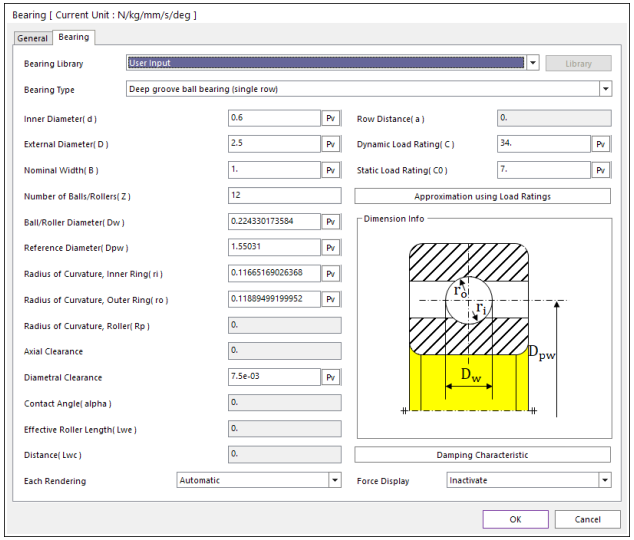
6. RecurDyn/DriveTrain – BearingKS (1)

1. **Intuitive bearing modeler**
2. **Bearing creation using user input parameters**
3. **Estimates internal geometry parameters of bearing based on diameter and load rating of ball and roller**
4. **Provides position, velocity, acceleration, and reaction force of bearing at each point in time of analysis**







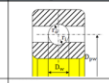
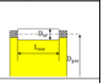
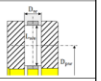
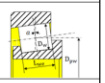
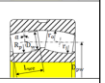
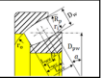


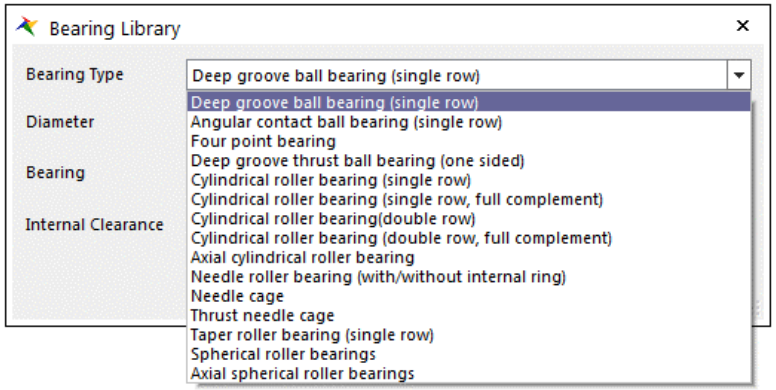
6. RecurDyn/DriveTrain – BearingKS (2)

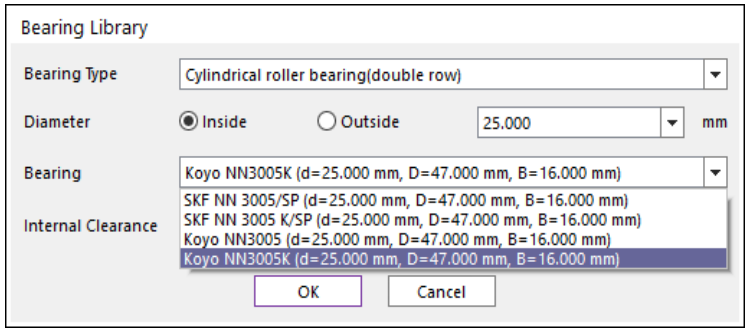
5. 15 different types of bearings (ISO/TS 16281)

6. Provides bearing database of 8 global brands

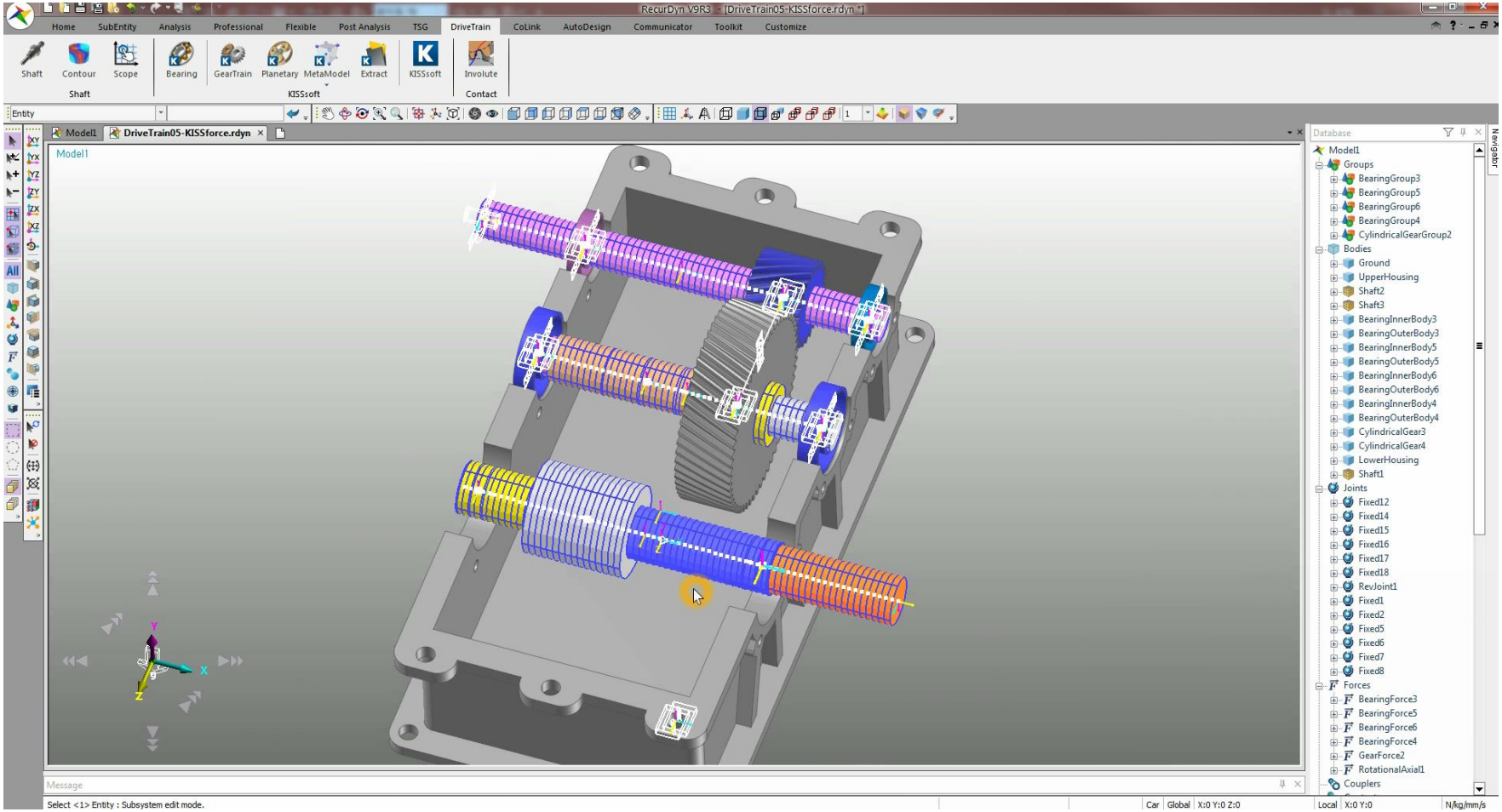
1) SKF, IBC, TIMKEN, KOYO, KRW, NSK, FAG, INA
2) Bearing creation with tens of thousands of libraries

Bearing Types	Bearing Section View	Bearing Types	Bearing Section View	Bearing Types	Bearing Section View
Deep groove ball bearing (Single row)		Cylindrical roller bearing (Single row, Full complement)		Needle cage	
Angular contact ball bearing (Single row)		Cylindrical roller bearing (Double row)		Thrust needle cage	
Four point bearing		Cylindrical roller bearing (Double row, Full complement)		Tapered roller bearing (Single row)	
Deep groove thrust ball bearing (One sided)		Axial cylindrical roller bearing		Spherical roller bearing	
Cylindrical roller bearing (Single row)		Needle roller bearing (with/without internal ring)		Axial spherical roller bearing	



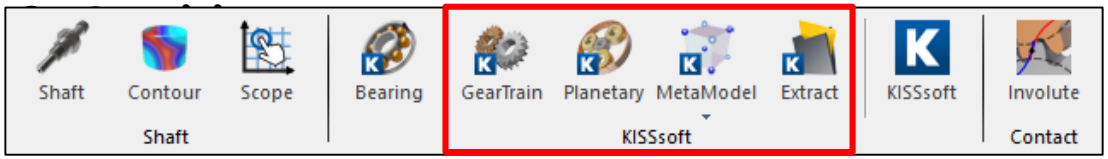


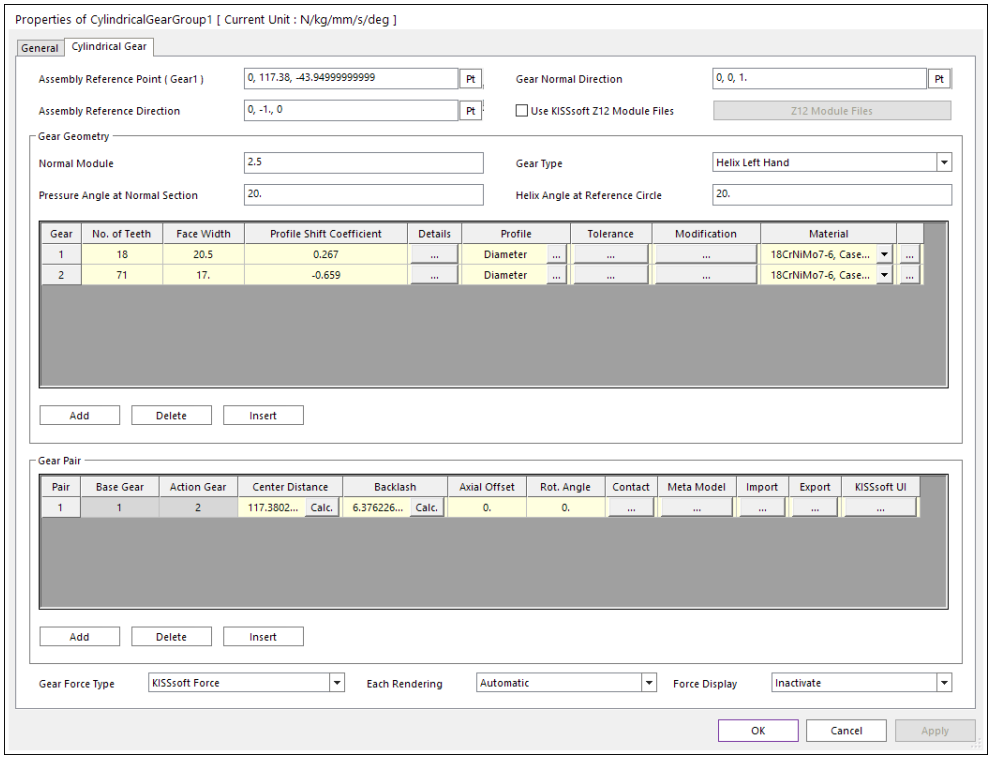
6. RecurDyn/DriveTrain – BearingKS (Modeling Demo)

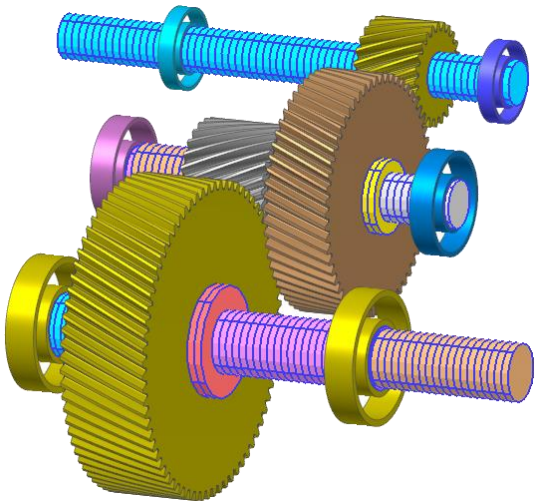


7. RecurDyn/DriveTrain – GearKS (1)

1. Gear Analytic Contact specialized for gear analysis (SMP (Symmetric Multiprocessing) up to 16 cores is supported)
2. Provides various gear analysis results including Transmission Error (TE)

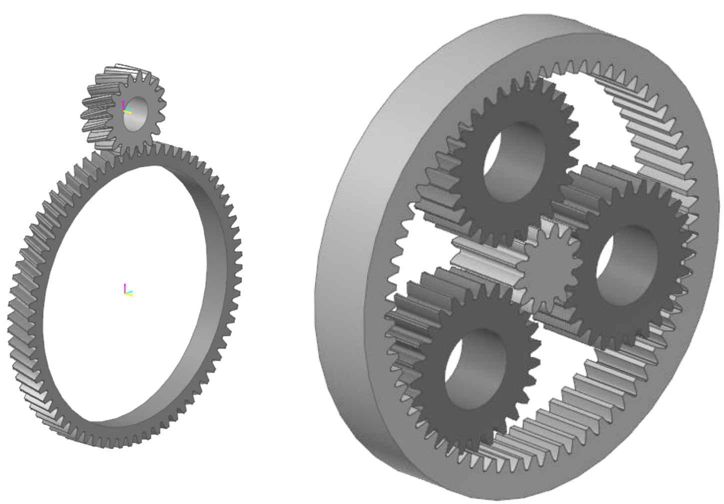


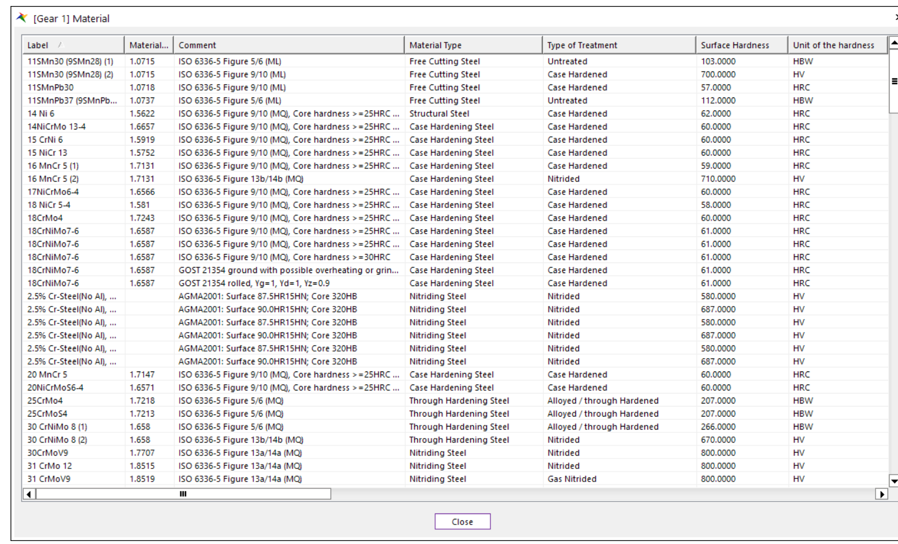




7. RecurDyn/DriveTrain – GearKS (2)

4. Supports Spur Gear, Helical Gear, and Planetary Gear
5. Supports gear geometry and detailed tooth modeling
6. Provides various Tooth Tolerance libraries and Material libraries
7. Automatic calculation of gear backlash based on inputs





[Gear 1] Material

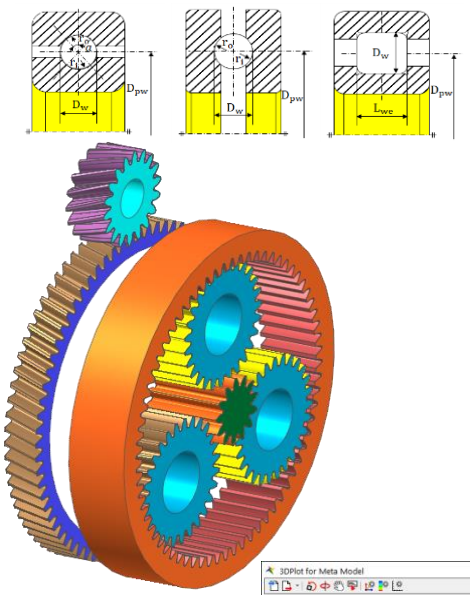
Label	Material...	Comment	Material Type	Type of Treatment	Surface Hardness	Unit of the hardness
11SMn30 (9SMn28) (1)	1.0715	ISO 6336-5 Figure 5/6 (ML)	Free Cutting Steel	Untreated	103.0000	HBW
11SMn30 (9SMn28) (2)	1.0715	ISO 6336-5 Figure 9/10 (ML)	Free Cutting Steel	Case Hardened	700.0000	HV
11SMnPb30	1.0718	ISO 6336-5 Figure 9/10 (ML)	Free Cutting Steel	Case Hardened	57.0000	HRC
11SMnPb37 (9SMnPb...	1.0737	ISO 6336-5 Figure 5/6 (ML)	Free Cutting Steel	Untreated	112.0000	HBW
14 Ni 6	1.5622	ISO 6336-5 Figure 9/10 (MQ), Core hardness >=25HRC ...	Structural Steel	Case Hardened	62.0000	HRC
14NiCrMo 13-4	1.6657	ISO 6336-5 Figure 9/10 (MQ), Core hardness >=25HRC ...	Case Hardening Steel	Case Hardened	60.0000	HRC
15 CrNi 6	1.5919	ISO 6336-5 Figure 9/10 (MQ), Core hardness >=25HRC ...	Case Hardening Steel	Case Hardened	60.0000	HRC
15 NiCr 13	1.5752	ISO 6336-5 Figure 9/10 (MQ), Core hardness >=25HRC ...	Case Hardening Steel	Case Hardened	60.0000	HRC
16 MnCr 5 (1)	1.7131	ISO 6336-5 Figure 9/10 (MQ), Core hardness >=25HRC ...	Case Hardening Steel	Case Hardened	59.0000	HRC
16 MnCr 5 (2)	1.7131	ISO 6336-5 Figure 13b/14b (MQ)	Case Hardening Steel	Nitrided	710.0000	HV
17NiCrMo6-4	1.6566	ISO 6336-5 Figure 9/10 (MQ), Core hardness >=25HRC ...	Case Hardening Steel	Case Hardened	60.0000	HRC
18 NiCr 5-4	1.581	ISO 6336-5 Figure 9/10 (MQ), Core hardness >=25HRC ...	Case Hardening Steel	Case Hardened	58.0000	HRC
18CrMo4	1.7243	ISO 6336-5 Figure 9/10 (MQ), Core hardness >=25HRC ...	Case Hardening Steel	Case Hardened	60.0000	HRC
18CrNiMo7-6	1.6587	ISO 6336-5 Figure 9/10 (MQ), Core hardness >=25HRC ...	Case Hardening Steel	Case Hardened	61.0000	HRC
18CrNiMo7-6	1.6587	ISO 6336-5 Figure 9/10 (MQ), Core hardness >=25HRC ...	Case Hardening Steel	Case Hardened	61.0000	HRC
18CrNiMo7-6	1.6587	ISO 6336-5 Figure 9/10 (MQ), Core hardness >=30HRC	Case Hardening Steel	Case Hardened	61.0000	HRC
18CrNiMo7-6	1.6587	GOST 21354 ground with possible overheating or grin...	Case Hardening Steel	Case Hardened	61.0000	HRC
18CrNiMo7-6	1.6587	GOST 21354 rolled, Yg=1, Yd=1, Yz=0.9	Case Hardening Steel	Case Hardened	61.0000	HRC
2.5% Cr-Steel(No Al), ...		AGMA2001: Surface 87.5HR15HN; Core 320HB	Nitriding Steel	Nitrided	580.0000	HV
2.5% Cr-Steel(No Al), ...		AGMA2001: Surface 90.0HR15HN; Core 320HB	Nitriding Steel	Nitrided	687.0000	HV
2.5% Cr-Steel(No Al), ...		AGMA2001: Surface 87.5HR15HN; Core 320HB	Nitriding Steel	Nitrided	580.0000	HV
2.5% Cr-Steel(No Al), ...		AGMA2001: Surface 90.0HR15HN; Core 320HB	Nitriding Steel	Nitrided	687.0000	HV
2.5% Cr-Steel(No Al), ...		AGMA2001: Surface 87.5HR15HN; Core 320HB	Nitriding Steel	Nitrided	580.0000	HV
2.5% Cr-Steel(No Al), ...		AGMA2001: Surface 90.0HR15HN; Core 320HB	Nitriding Steel	Nitrided	687.0000	HV
20 MnCr 5	1.7147	ISO 6336-5 Figure 9/10 (MQ), Core hardness >=25HRC ...	Case Hardening Steel	Case Hardened	60.0000	HRC
20NiCrMoS6-4	1.6571	ISO 6336-5 Figure 9/10 (MQ), Core hardness >=25HRC ...	Case Hardening Steel	Case Hardened	60.0000	HRC
25CrMo4	1.7218	ISO 6336-5 Figure 5/6 (MQ)	Through Hardening Steel	Alloyed / through Hardened	207.0000	HBW
25CrMoS4	1.7213	ISO 6336-5 Figure 5/6 (MQ)	Through Hardening Steel	Alloyed / through Hardened	207.0000	HBW
30 CrNiMo 8 (1)	1.658	ISO 6336-5 Figure 5/6 (MQ)	Through Hardening Steel	Alloyed / through Hardened	266.0000	HBW
30 CrNiMo 8 (2)	1.658	ISO 6336-5 Figure 13b/14b (MQ)	Through Hardening Steel	Nitrided	670.0000	HV
30CrMoV9	1.7707	ISO 6336-5 Figure 13a/14a (MQ)	Nitriding Steel	Nitrided	800.0000	HV
31 CrMo 12	1.8515	ISO 6336-5 Figure 13a/14a (MQ)	Nitriding Steel	Nitrided	800.0000	HV
31 CrMoV9	1.8519	ISO 6336-5 Figure 13a/14a (MQ)	Nitriding Steel	Gas Nitrided	800.0000	HV

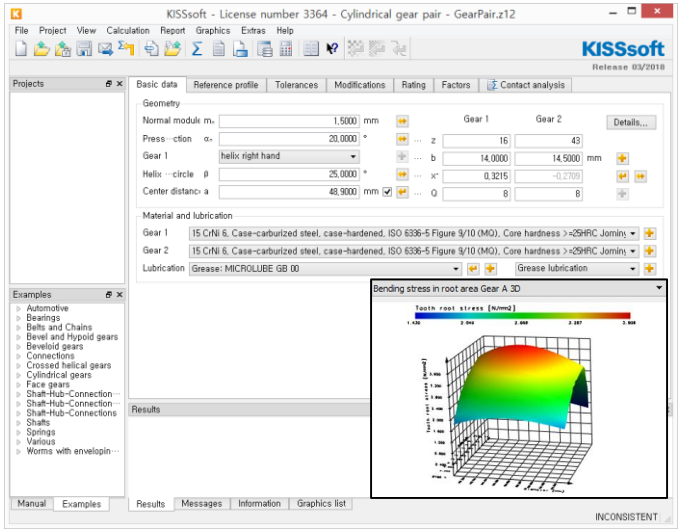
Close

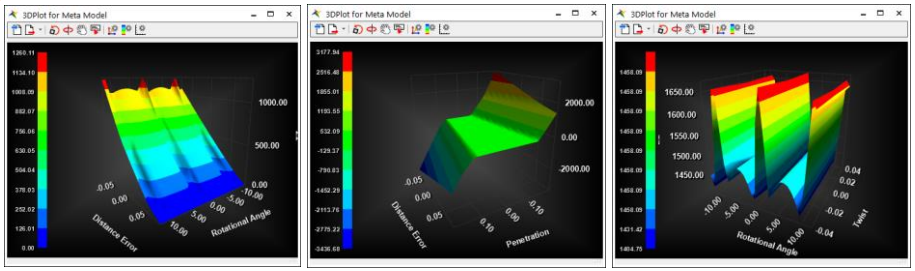
7. RecurDyn/DriveTrain – GearKS (3)

8. Detailed modeling/analysis/post-processing through built-in KISSsoft UI

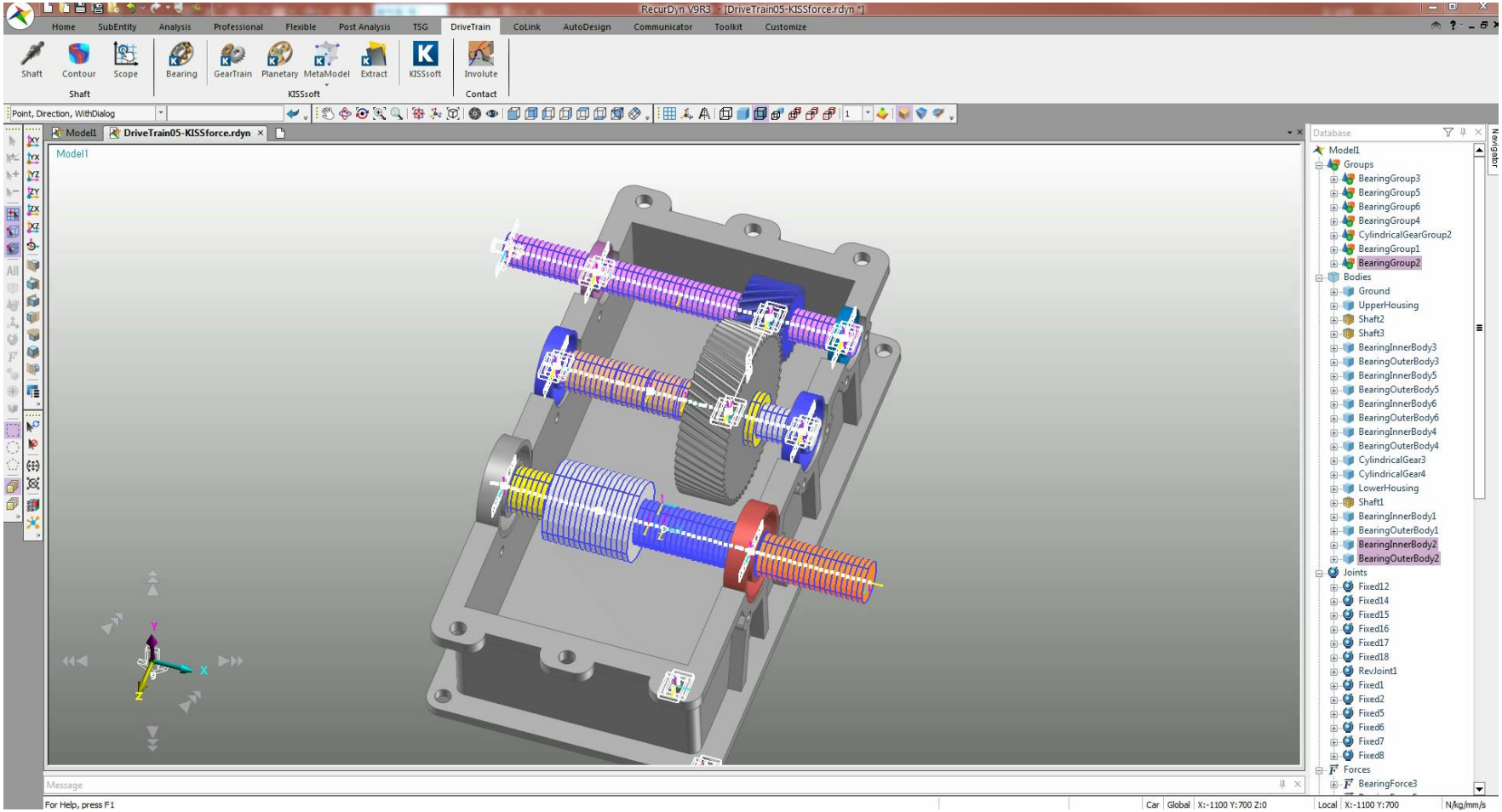
- Precise gear design with parameters used for actual gear design
- Interoperability of the gear models between KISSsoft and RecurDyn
- Supports gear static analysis
- Various results such as stress distribution on the gear tooth surface



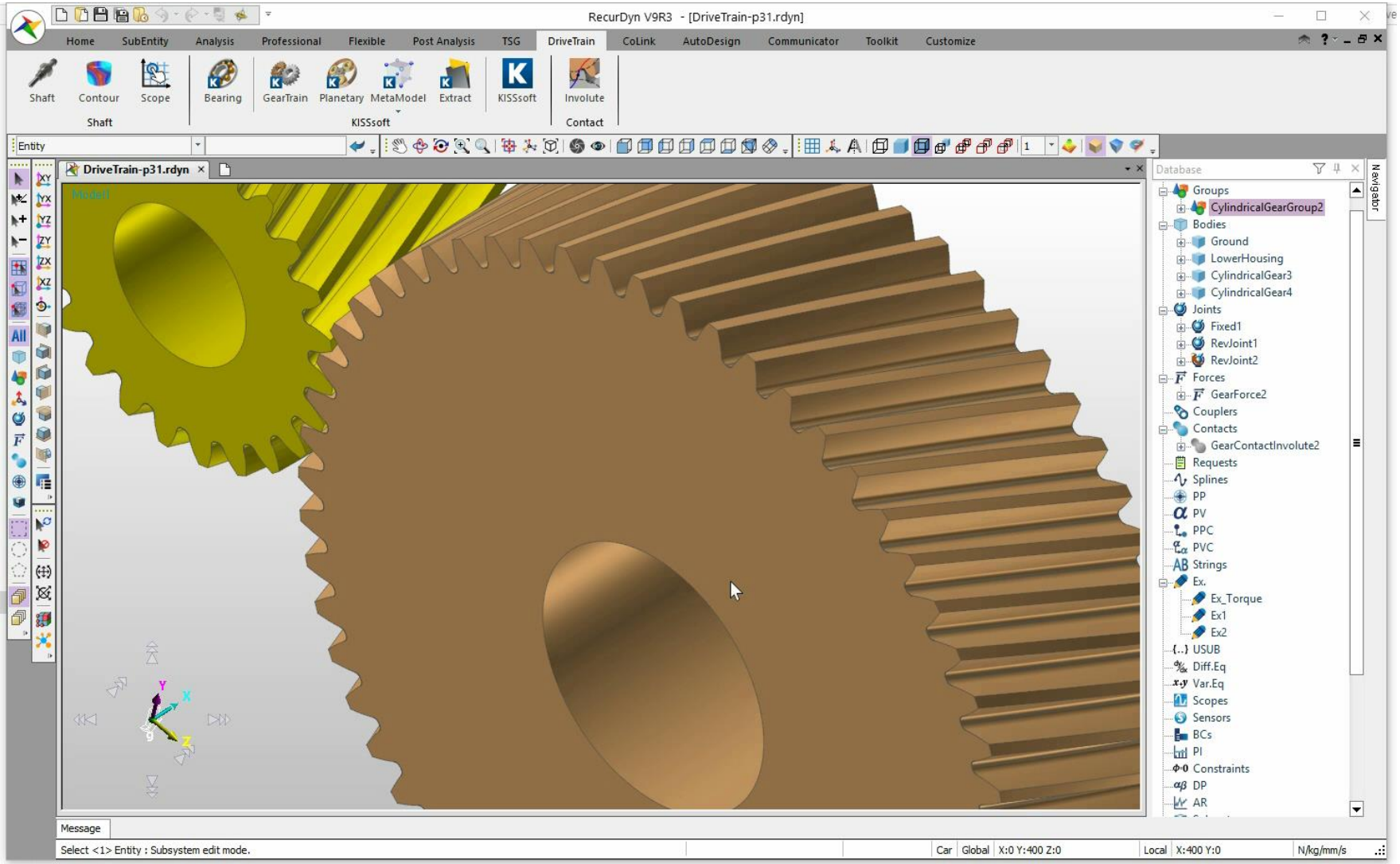




7. RecurDyn/DriveTrain – GearKS (Modeling Demo)



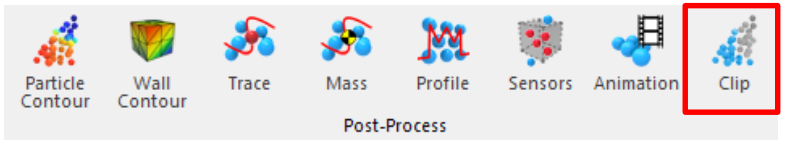
8. Embedded KISSsoft GUI Demo

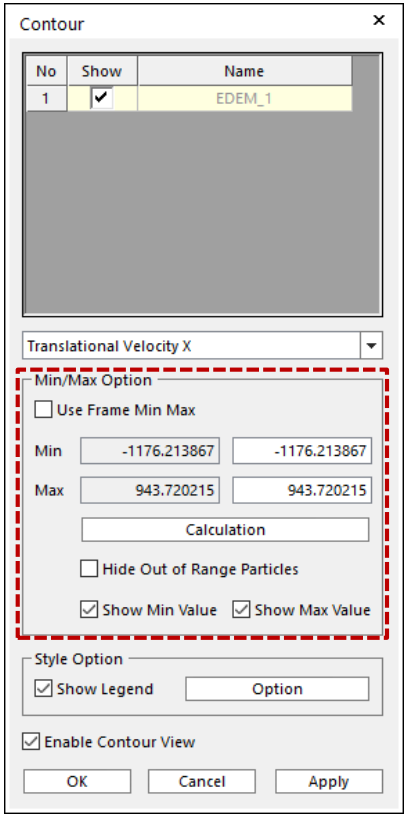


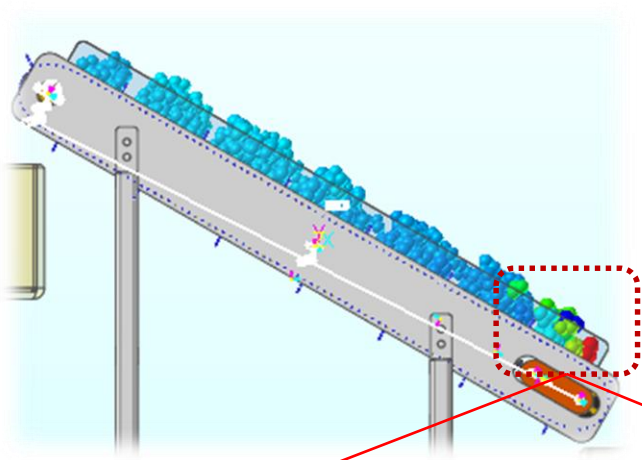
Other Toolkits

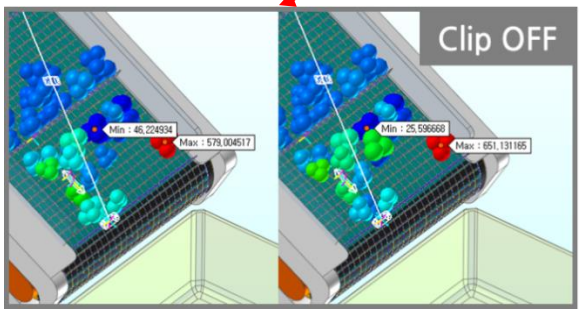
1. Particleworks I/F, EDEM I/F – Clip Particles

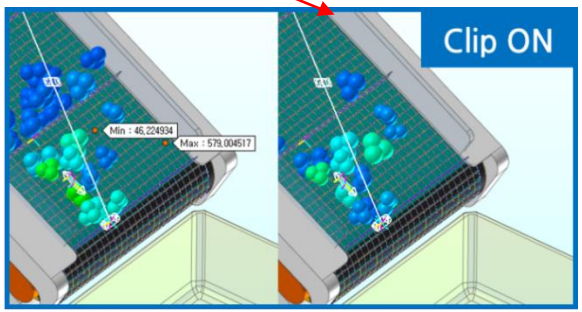
Hide particles that fall outside the user-specified range of results during animation in Particleworks I/F and EDEM I/F







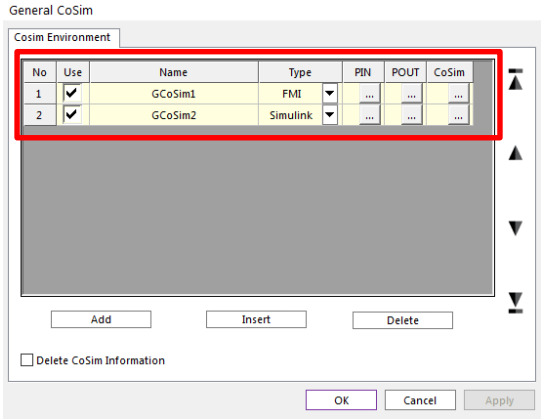




2. RecurDyn/Control & RecurDyn CoLink

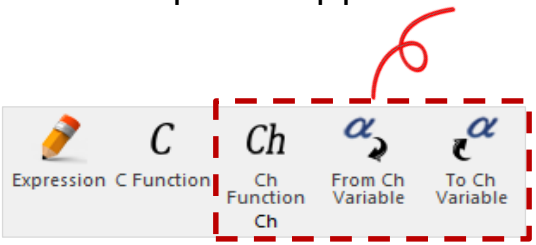
1. Control

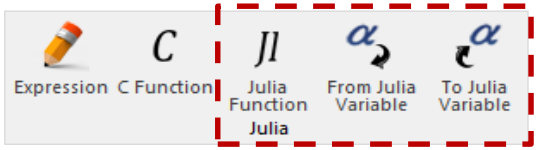
1) Direct interface with AMESim is obsoleted
   A. FMI (Functional Mock-up Interface) can be used instead
2) Multi-Cosim supports Simulink



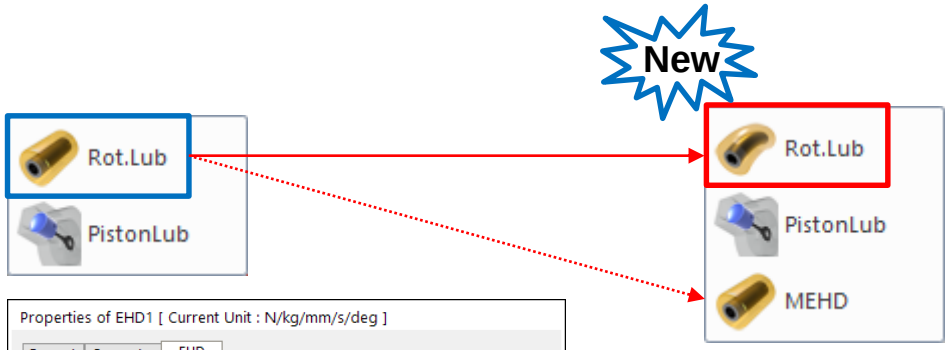
2. CoLink

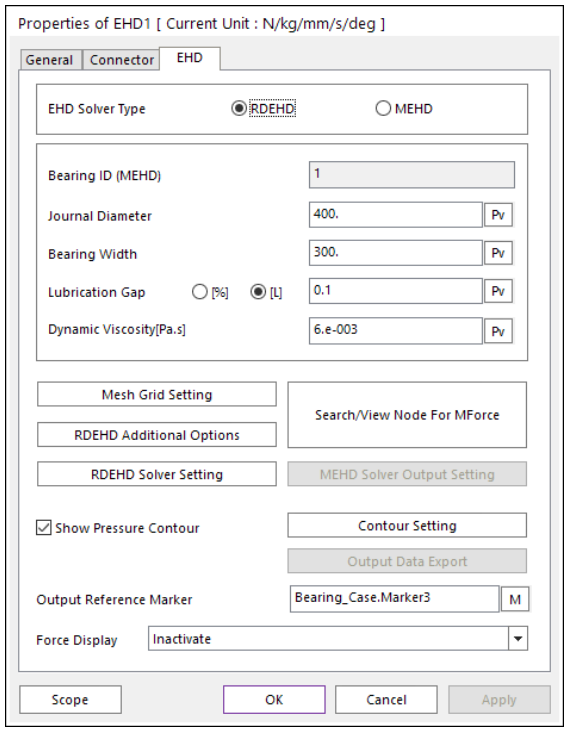
1) Ch-Script is obsoleted
2) Julia-Script is supported instead



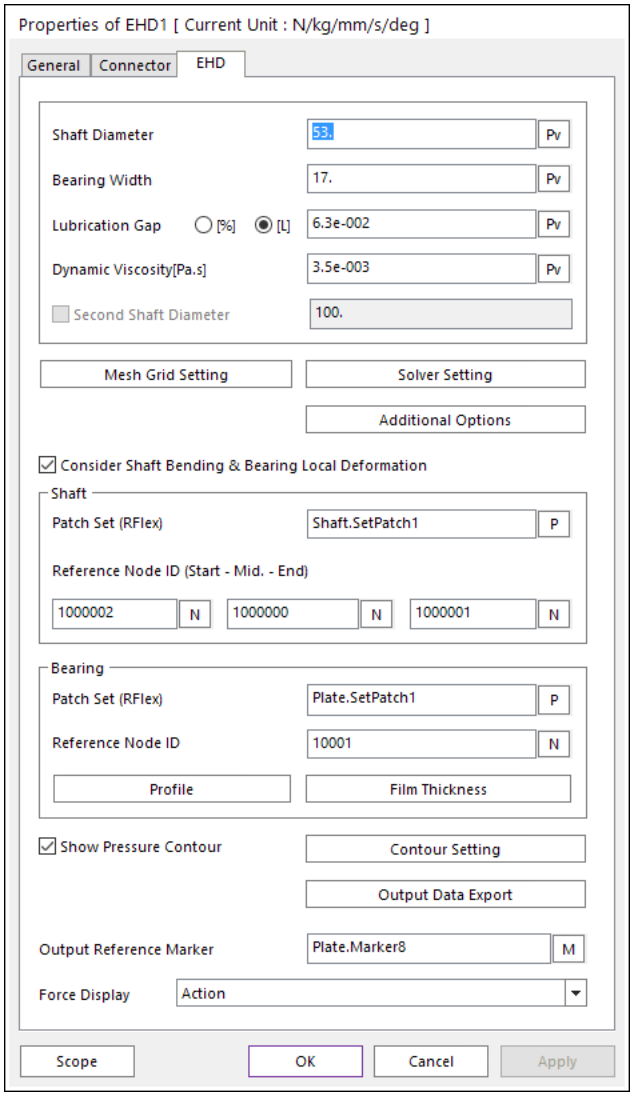


3. RecurDyn/EHD – Rotational Lubrication (1)



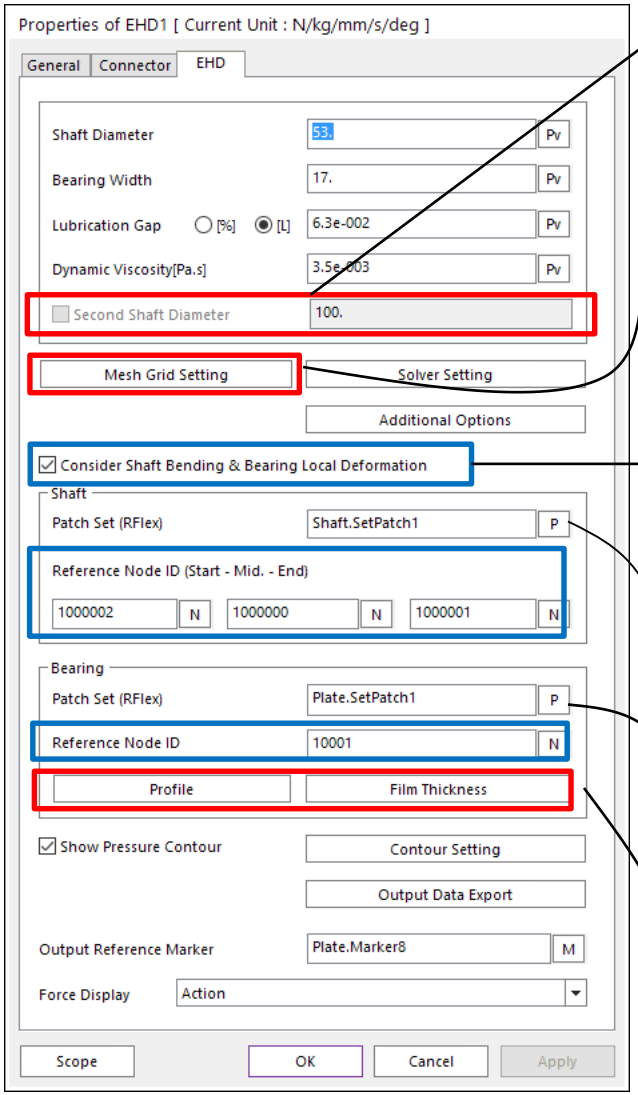


V9R2

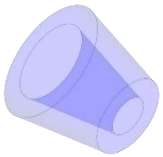


V9R3

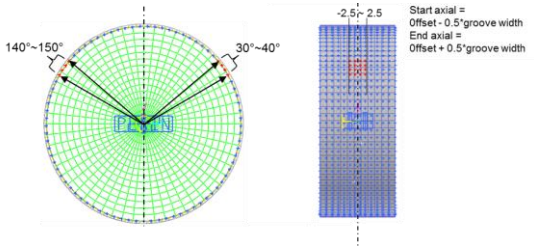
3. RecurDyn/EHD – Rotational Lubrication (2)



Cone-shaped EHD
Second Shaft Diameter (Support Rigid Body)

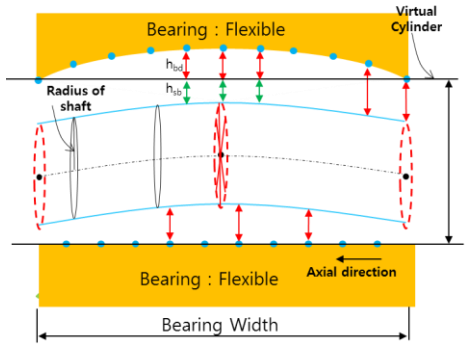


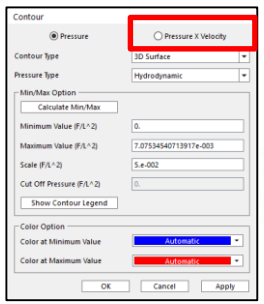
Oil Hole & Groove Effects Setting
(Angle, Axial Position & Range)

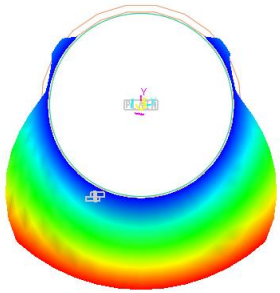


Consider Flexibility using Bearing & Shaft RFlex Body
(thickness calculation considering Bearing Deformation, Shaft Bending

h_{bd} (↕): Thickness by bearing deformation
h_{sb} (↕): Thickness by shaft bending



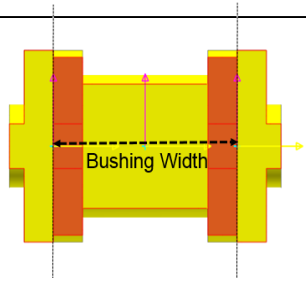


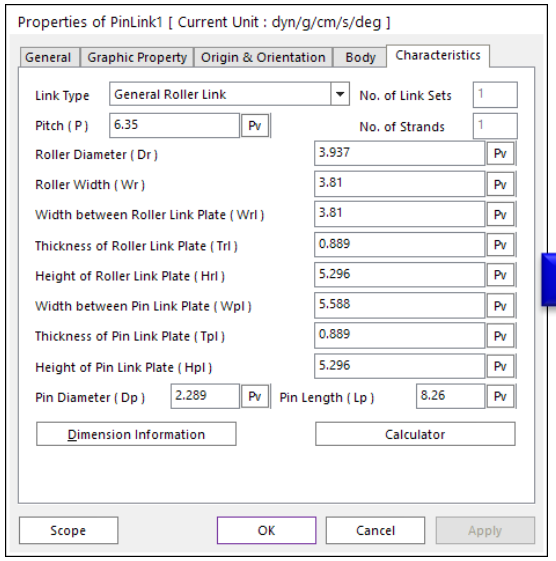


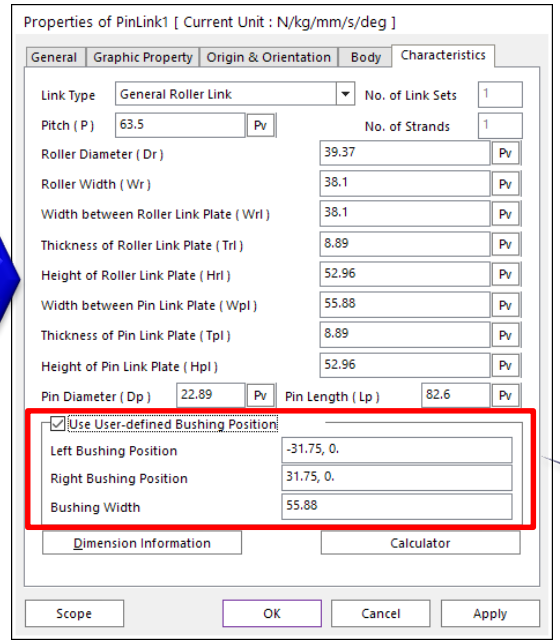
Patch set where the force by lubrication is applied

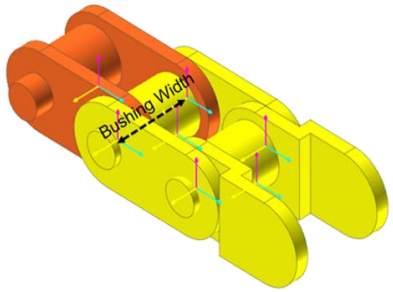
Profile: offset from Bearing Grid Position
Film Thickness: Set Pressure to 0 if bigger than specified value

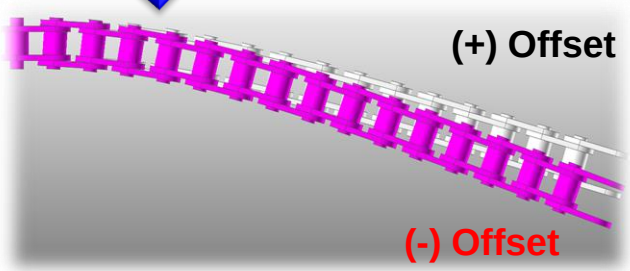
4. RecurDyn/Chain - User-defined Bushing Position









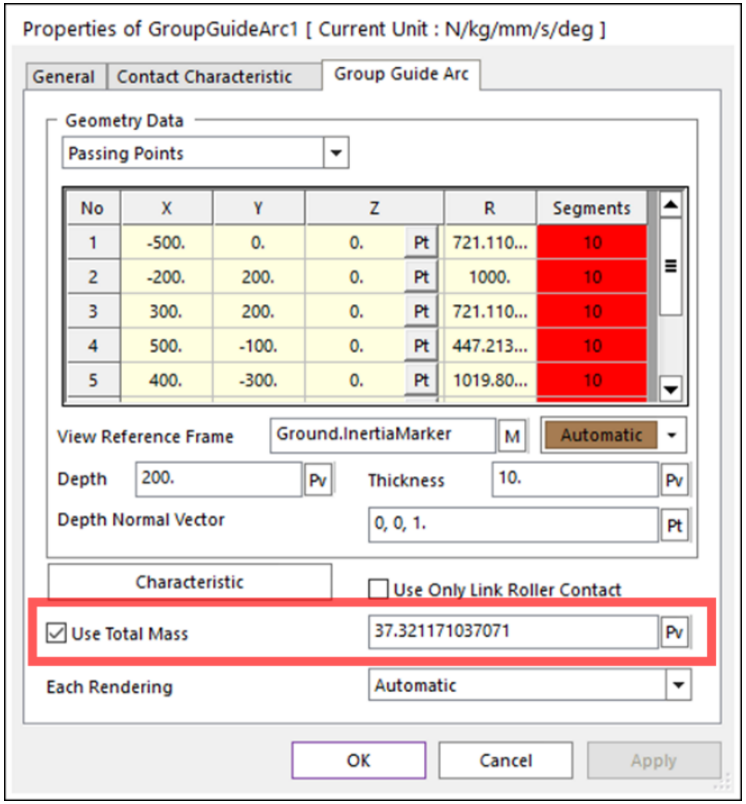


V9R2

V9R3

5. RecurDyn/Chain – Use Total Mass

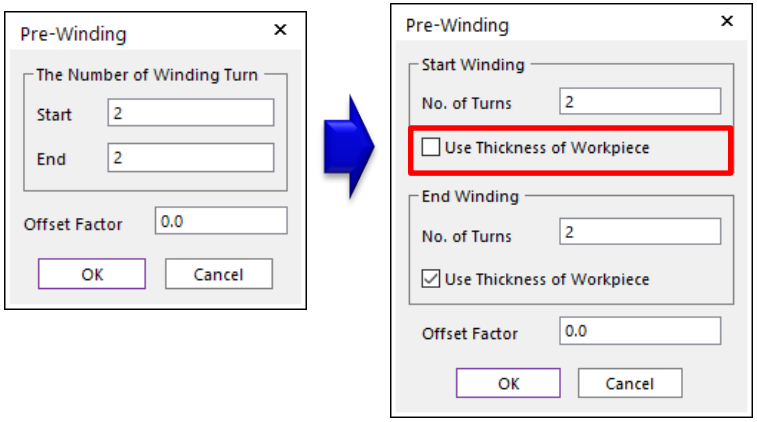
Total Mass option allows a chain's entire mass to be distributed evenly to each Guide that makes up the Group Guide



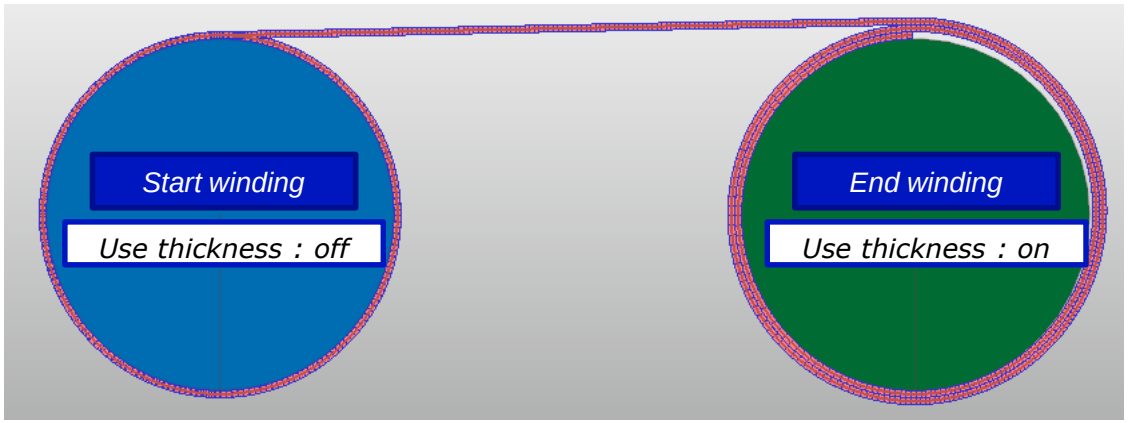
6. RecurDyn/R2R – Assembly without self-contact

1. User can ignore the self-contact → reduce the simulation time

1) Check off 'Use Thickness of Workpiece



V9R2 **V9R3**




Particleworks
CFD
FEA
MBD
MFBD
DEM
Control
MBS-FE Coupling
EDEM
CoLink
FMI
Simulink
SimulationX
AMESim
Simplorer

Others

Other enhancements

1. **ProcessNet**
   1) Frequency Response Analysis
   2) Geometry Export

2. **New Tutorials**
   1) Acoustics tutorial
   2) Particleworks interface tutorial (water sloshing)

Please refer to the release note for the other changes.

RECURDYN Connect to All

Thank you

Connect to All

Multidisciplinary integrated analysis solution implemented in one environment

Self-contained solution for multidisciplinary integration including MFBD, CoLink and AutoDesign

Scalability through connection with analysis solutions

- **FEA** – MFBD, G-Modeling, Durability, MBD for ANSYS
- **CFD** - Particleworks (fluid particles) EHD (lubrication)
- **Control** – CoLink, Simulink, FMI, AMESim, SimulationX, Simplorer
- **DEM** - EDEM (solid particles)
- **Optimization** – AutoDesign, Mode Frontier
- **Customization** – Excel, C#
- **Others –** KISSsoft (Gear/Bearing), TSG toolkit (experimental data)