New CAE Paradigm,

DAFUL/MeshFree

Abstracts of Presentation

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1	Improved DAFUL/MeshFree and Case Studies	D.S. Bae (Professor)	VirtualMotion
2	New Functionalities of DAFUL5.1	H.J. Cho (Director)	VirtualMotion
3	NVH Analysis of Gear System using DAFUL/Geartrain Toolkit	W.G. Kim (Team Leader)	VirtualMotion
4	Vehicle Dynamics Analysis considering Flexibility	Y.H. Lee (Chief Eng.)	Ssangyong Motor
5	Whine Noise Analysis of Auto Transmission System	W.J. Kim (Chief Eng.)	Hyundai Power Tech
6	Clutch-Pedal Performance Simulation using MBD Technique	J.H. Cho (Chief Eng.)	PH Valeo
7	Life prediction method of wheel bearings	S.P. Lee (Chief Eng.)	ILJIN Global

Virtual **Motion**
CAE Solution Business

• You can have new experience in the structural analysis using DAFUL/MeshFree. This presentation will show how to use DAFUL/MeshFree, what functionalities are supported and its solution is reliable. In the new version, DAFUL/MeshFree has been remarkably improved in view of required memory and solving speed. Several examples will be introduced to verify new solver. Adoptive local refinement will give more reliable solution while requiring less memory and reducing a solving time. Several field examples are introduced to verify the usability of DAFUL/MeshFree.

Easy Modeling and Analysis

✓ STEP 1 : Import CAD

✓ STEP 2 : Input Material Properties

✓ STEP 3 : Boundary Condition Modeling on a face

✓ STEP 4 : Run Analysis

✓ STEP 5 : Report Outputs

STEP 1
STEP 2
STEP 3
STEP 4
STEP 5

Name	MAT_BearingH_Lower
Density	7.80E-06
Damping Ratio	0.001
Young's Modulus	191960
Shear Modulus	74403.1
Poisson's Ratio	0.29

Adoptive Local Refinement

Level	Node Distance (Approx.) X	Y	Z
1	5	5	5
2	2.5	2.5	2.5
3	1.25	1.25	1.25
4	0.625	0.625	0.625
5	0.3125	0.3125	0.3125
6	0.15625	0.15625	0.15625
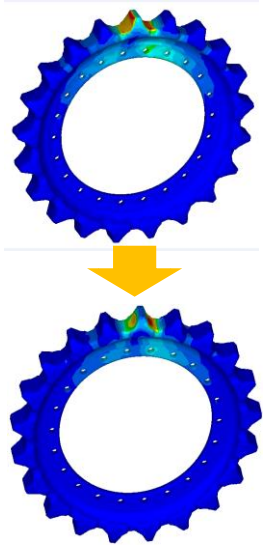
Powerful Performance

FEM – 1,000,000
DAFUL5.0
DAFUL5.1 (L4:90%,L5:10%)
DAFUL5.1 (L4:95%,L6:5%)
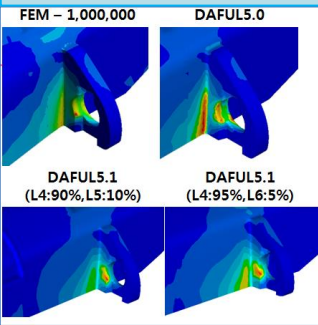
	FEM	DAFUL5.0 (LV5-D8192)	DAFUL5.1 (LV4)		DAFUL5.1 (L4:90%,L5:10%)		DAFUL5.1 (L4:95%,L5:5%)	
No. of Node	1,000,000	483,768	381,819		780,000		830,000	
Max. Deformation (mm)	0.277	0.289	4.3%	0.267	-3.6%	0.296	6.8%	0.296	6.8%
Max. V.M. Stress (MPa)	46.18	28.0	-39%	31.0	-33%	41.04	-11%	47.69	+3%
Required Memory (GB)	68	63	1.08	9.1	7.5	18	3.8	18	3.8
Solving Time (Min.)	28	31	0.9	8.5	3.3	16	1.75	19	1.47

Accuracy

	MeshFree (Hz | %)		FE (Hz)	MeshFree	FE
1st	193.76	-1.60 %	196.92		
2nd	212.20	3.20 %	205.61		
3rd	227.48	-0.62 %	228.91		
4th	269.97	4.20 %	259.07		
5th	294.80	-1.2 %	298.60		

• New functions in DAFUL5.1 are introduced and demonstrated. Journal and CAD replace functions will give new standard for modeling automation. When a CAD is changed, the tedious and routine modeling work is not required to simulate the DAFUL model. For the chained/tracked system, contour display and stacked bar chart of tension and loss helps to analyze the dynamics behavior of system with a visualization. Also, the mode contribution analysis for the system or specified flexible body are new challenge in the vibration analysis.

DAFUL/Geartrain Toolkit

• Geartrain toolkit has been developed to a vibration analysis of various gear mechanisms. This toolkit consists of various entities such as shaft set, gear set, bearing, assembly and so on. Shaft set, gear set and bearing can be modeled in 2D viewer of designer. By defining several parameters, you can get the gear mesh stiffness which is calculated with FEM and the stiffness matrix o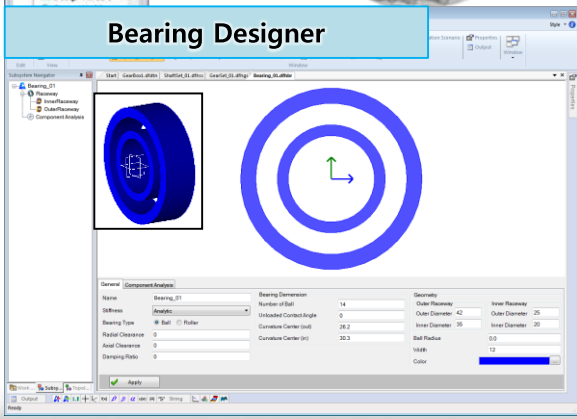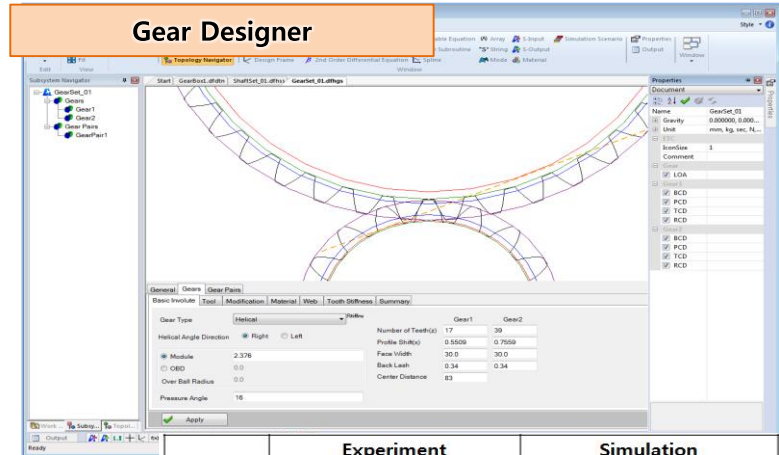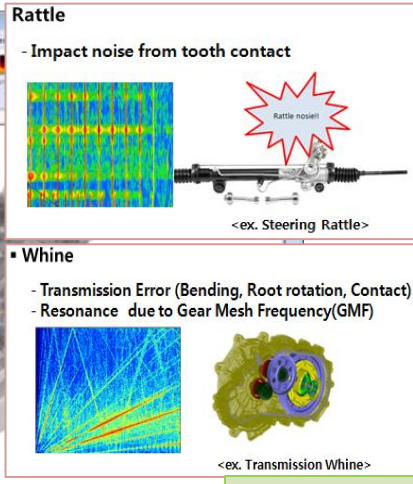f roller or ball bearings can be calculated analytically. The dynamics analysis of the assembled system gives various information such as dynamic peak-to-peak transmission error, acceleration, bearing force and so on. Color map and order tracking are supported in the post-processor.

Geartrain Toolkit

Rattle
- Impact noise from tooth contact

Rattle noise!!

<ex. Steering Rattle>

▪ Whine
- Transmission Error (Bending, Root rotation, Contact)
- Resonance due to Gear Mesh Frequency(GMF)

<ex. Transmission Whine>

Gear Designer

Experiment | Simulation

Waterfall

Color Map and Order Tracking

Bearing Designer

Shaft Set

1st mesh | 2nd mesh

Order Tracking

Vehicle Dynamics Analysis considering Flexibility
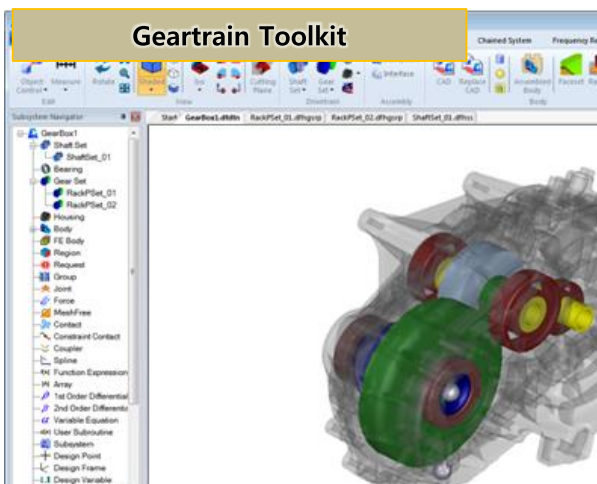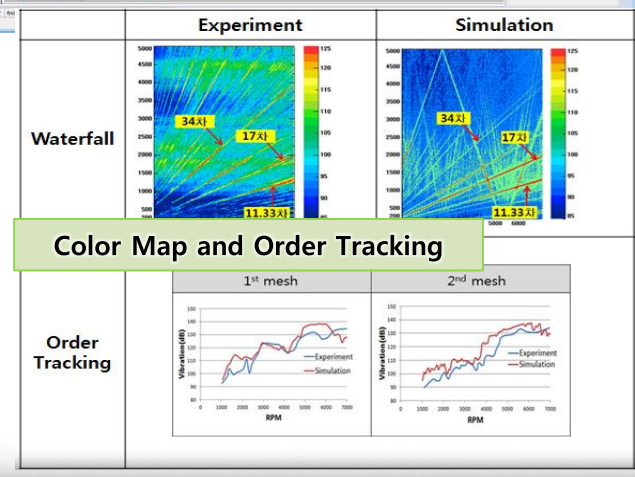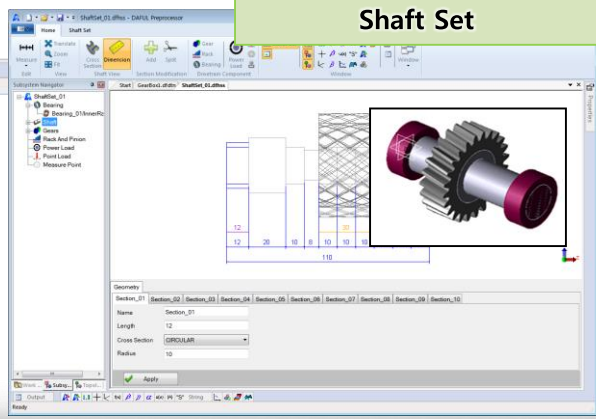
• Multi-body dynamics analysis has been widely used to estimate the vehicle K&C and R&H performance. Step and impulse steer, steady-state turn, ISO lane change, fish hook, return-ability and cross wind simulations are carr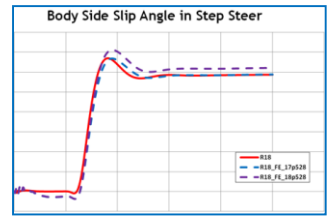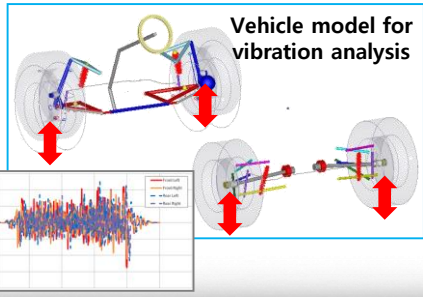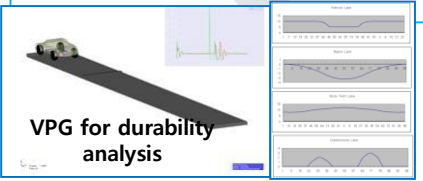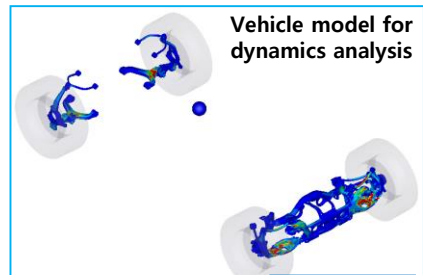ied out to test the riding and handling of the vehicle. The shimmy and 4-post analysis are carried out to test the vibration of the vehicle. The virtual proving ground has been developed for the durability analysis of main parts. For above simulations, almost parts of vehicle model are defined as a modal flexible body. The flexible bodies can be created by using the MeshFree method. Several sheet parts such as BIW are modeled by using FE bodies.
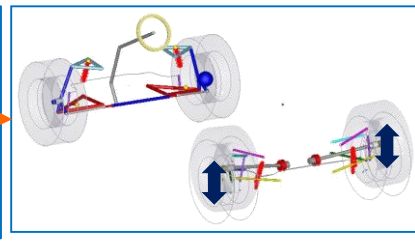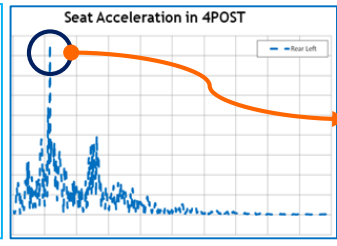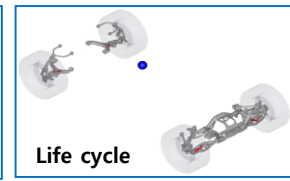
SsangYong Motor

Preview of Presentation

• Established in 1954.
• Korean automotive company building a full line of SUVs.
• Employee : 4,789
• Main Products
  • Rexton, Korando C, Tivoli, Korando Sports, Korando Turismo
  • Chairman W

• Global Network
  • The company exports its SUVs through some 1,290 sales outlets in over 106 countries
• Web : http://www.smotor.com/en/index.html

Vehicle model for dynamics analysis

VPG for durability analysis

Body Side Slip Angle in Step Steer

Roll Angle in Fish Hook
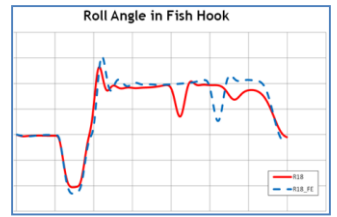
The difference between the conventional and the proposed methods

Dynamics stress

Life cycle

Vehicle model for vibration analysis

Seat Acceleration in 4POST
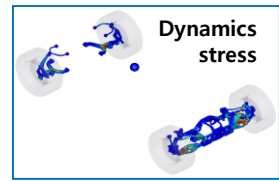
Frequency Response in Seat

Max. Contributed Mode

DAFUL PARADIGM CHANGE OF CAE

Whine Noise Analysis of Auto Transmission System

• In order to analyze the whine noise of a gear train system, the flexibility of housing, gear, bearing and shaft must be considered in the numerical analysis model. The gear deformation due to contact has been represented as the gear contact stiffness and its contact geometry is analytically represented with involute curve and several shape parameters. Also, the stiffness model of bearing can be analytically calculated. The shaft is modeled as multiple bodies and beam entities and the housing can be represented with the modal flexible body. For the transient input velocity and torque, the dynamics analysis is carried out to estimate the vibration on the housing. Order tracking technique has been used to extract the whine noise for the gear mesh frequency.
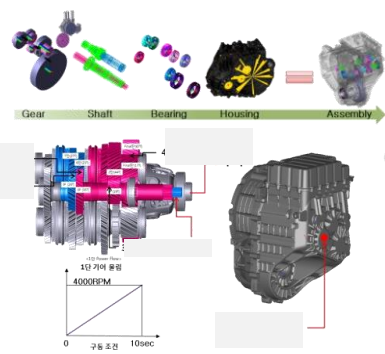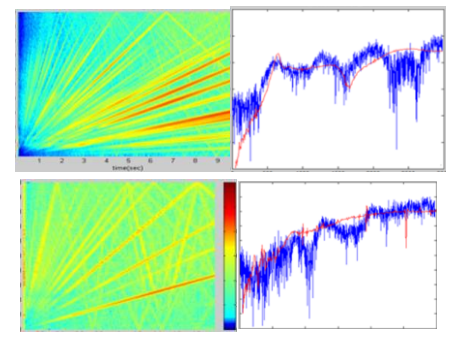
HYUNDAI POWERTECH

Preview of Presentation

• Established in 2001
• Headquarter is located in Korea.
• Employee : 1,882 (in 2014)
• Main Products
    • AT, CVT
• Main Customers : HMC, KMC, Chrysler
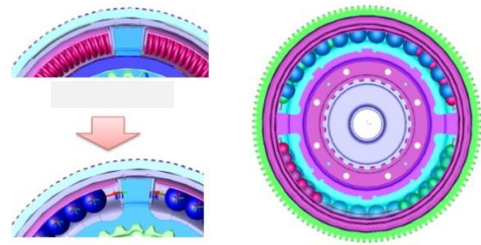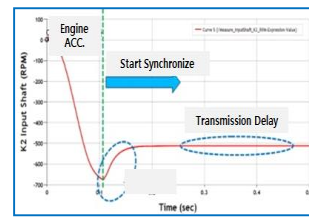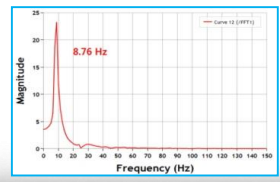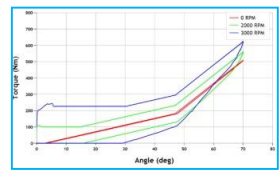• Applied Vehicles :

• Web : http://www.powertech.co.kr/

Transmission Model for NVH Analysis

Whine Noise and Order tracking

DMF Hysteresis and Frequency Response

Transmission Delay

Virtual Motion
CAE Solution Business

• This simulation tool has been developed to estimate the pedal performance and design a clutch stiffness and damping characteristics. Multi-body dynamics model has been developed to represent a pedal system. The model consists of three main parts such as pedal, hydraulic, and clutch. The characteristics curves of pedal spring and hydraulic part, and clutch are required for this simulation. The stiffness curve of the clutch are simulated using DAFUL FE Dynamics. Pedal performance can be defined as a travel-effort curve which estimate various pedal performance such as clutch response force, reverse stroke, pedal return sensitivity and so on.

VALEO Pyeong Hwa PHC Valeo

Preview of Presentation

• Established joint-venture with VALEO France in 1988.
• Headquarter is located in KOREA.
• Employee : 1,180
• Main Products
  • Clutch Disc, Clutch Cover
  • Release Bearing, Facing
  • SAT / SATIC Hydraulic Products
  • Torque Converter, DMF
• Main Customers

HYUNDAI KIA MOTORS GM KOREA TATA DAEWOO DAEWOO BUS SSANGYONG MOTOR RENAULT SAMSUNG
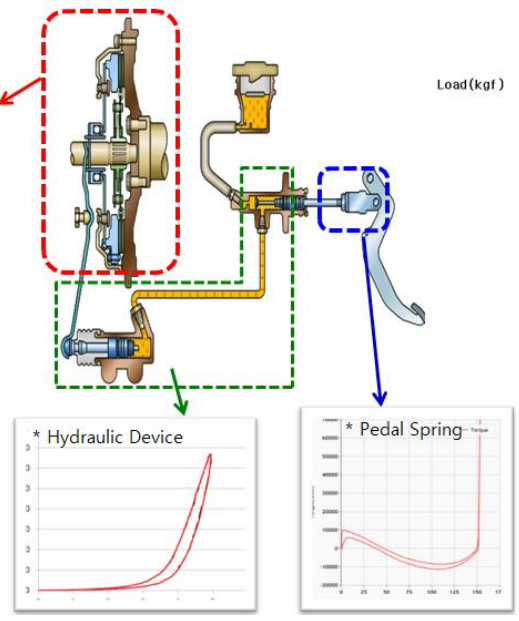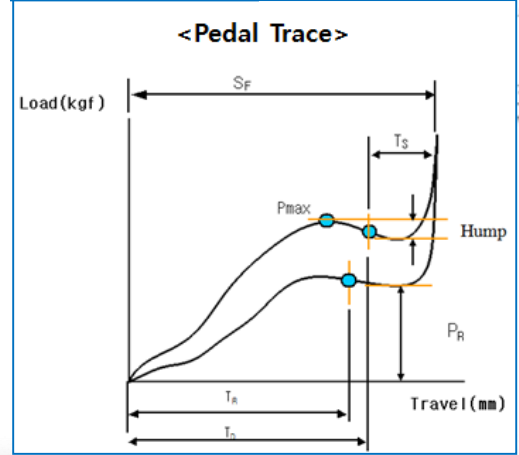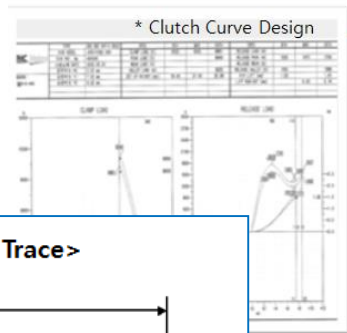
General Motors SUZUKI MITSUBISHI HONDA RENAULT FIAT NISSAN

• Web :
  http://www.vph.co.kr/doc/en_main.asp

Pmax	Max.Pedal Effort[kgf]
T_D	Declutching Travel[mm]
T_S	Stroke[mm]
P_R	Return Force[kgf]
T_R	Clutching Travel[mm]
S_F	Full Stroke

* Clutch Curve Design

<Pedal Trace>

* Hydraulic Device

* Pedal Spring

Life prediction method of wheel bearings

• Wheel bearing is one of the important parts of the car. Various studies have been conducted long time. However, prediction of the wheel bearing life has been used expression computation method using a theoretical formula between the raceway and ball. Such an approach, have assumed to be static load. It is not possible to consider the dynamics characteristics. Contact is defined the between the raceway and ball. It is possible to determine the load to the balls with the contact algorithm. And it can be predict the life of the wheel bearing through the load applied to the ball. Studied wheel bearing life prediction method is compare with the existing formula and static analysis result of the DAFUL.

ILJIN GLOBAL — ILJIN
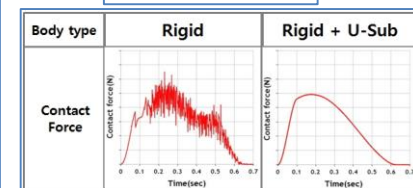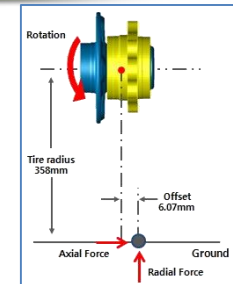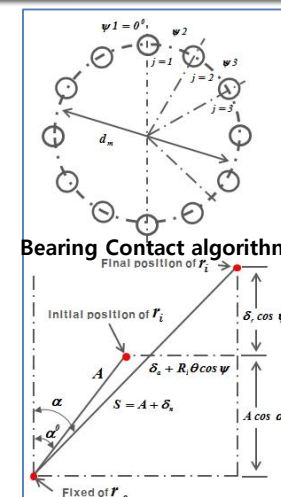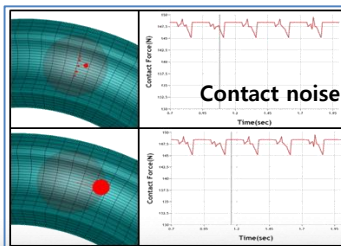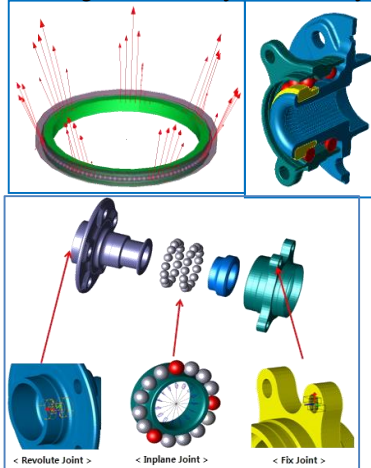
• Established in 1978.
• ILJIN has led the global wheel bearing market through growth and innovation.
• Employee : 4,789
• Main Products
   • Hub Unit Bearing, Slew Bearing, Bearing for Transmissions, Large Angular Contact Bearing,
   • Suspension/Steering System
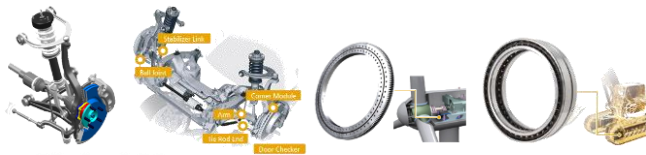
• Global Network
   • The company exports its SUVs through some 1,290 sales outlets in over 106 countries
• Web : https://www.iljin.com:449/English/

Preview of Presentation

Bearing model for dynamics analysis

< Revolute Joint >   < Inplane Joint >   < Fix Joint >

Bearing Contact algorithm

Contact noise

Virtual Test Lab

1. CAD 모델 구성   2. Modal 해석   3. 동역학 해석