

## 제 8 회 단조 심포지엄

### 회전 단조공정 해석기술 개발

문호근\*, 정재현\*, 전만수\*\*

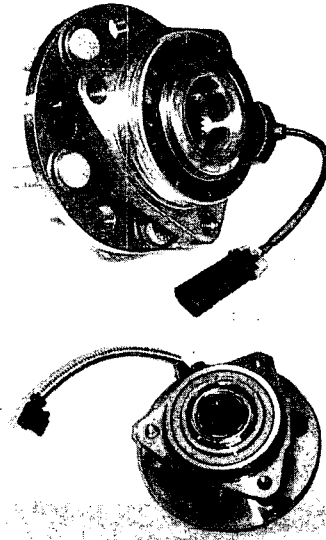
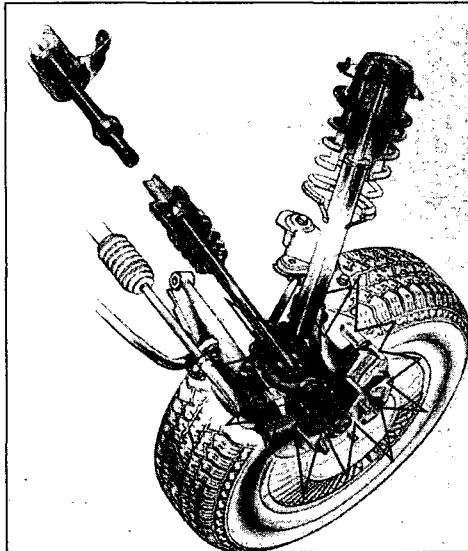
2003. 10. 16

\* FAG한화베어링㈜ 연구소

\*\* 경상대학교 기계항공공학부

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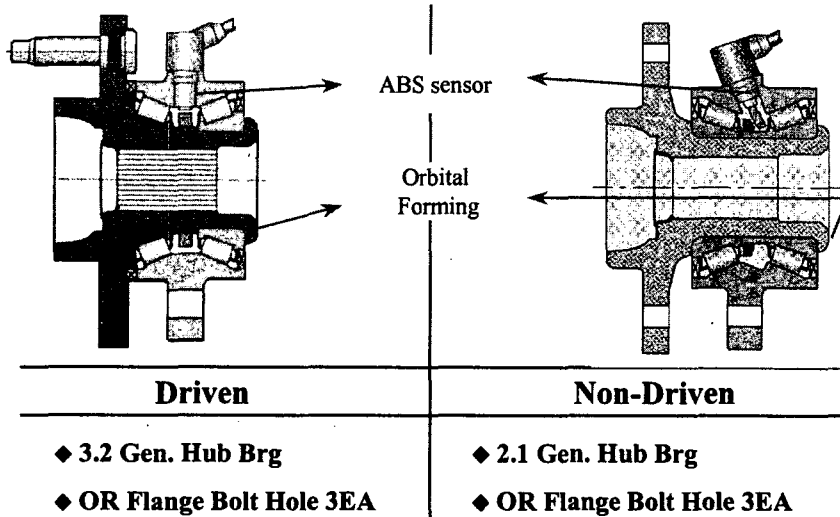
### Application : Wheel Bearing



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## Driven/Non-Driven Wheel Bearing



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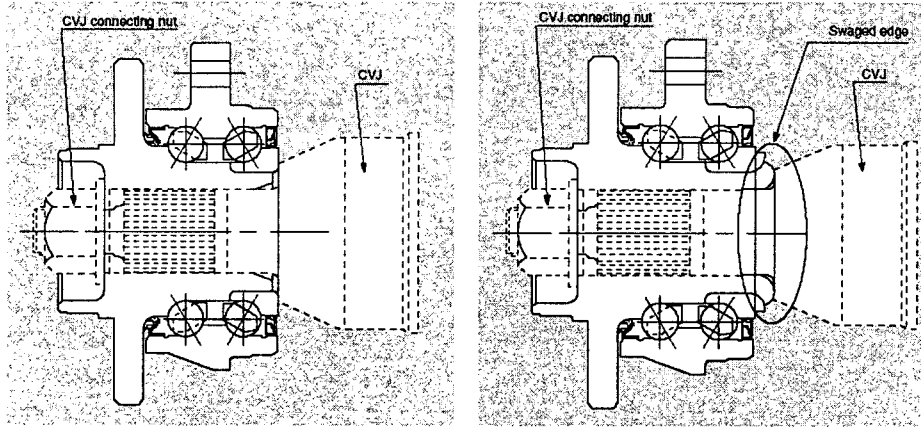
## Wheel Bearing Production Process

- Outer ring
  - Forging → Soft Turning → Induction Hardening → Fine Turning → 
  - Inspection → Raceway Grinding → Honing → Washing ●
- Inner ring 1,2
  - Forging → Soft Turing →  Inspection → Quenching → Side Grinding →
  - IR2 : Hard turning → Raceway, Width Grinding → Bore Grinding → Raceway honing → Washing → Bore & Width 100% Inspection ●
  - IR1 : Raceway, Width Grinding → Bore Grinding → Raceway honing → Washing → Bore & Width 100% Inspection ●
- Hub(Spindle)
  - Forging → Turning → Cold Rolling ↔
- Assemble
  - Matching : Direct matching → Insert Cage ←
  - Inspection : Axial clearance & No of ball tread of hub bolt after assemble → Noise inspection → Insert grease → Insert seal ●
- Final mounting
  - Force-Distance Inspection : After Flange mounting → Orbital forming → ABS seal Assembly → Inspection of ABS gab & Force-Distance & Eddy Current → Marking → Broaching → Face turning → Washing → Final Inspection : Radial run-out, Friction moment, Pre-load, Tread of spline → Insert ABS sensor → Packing

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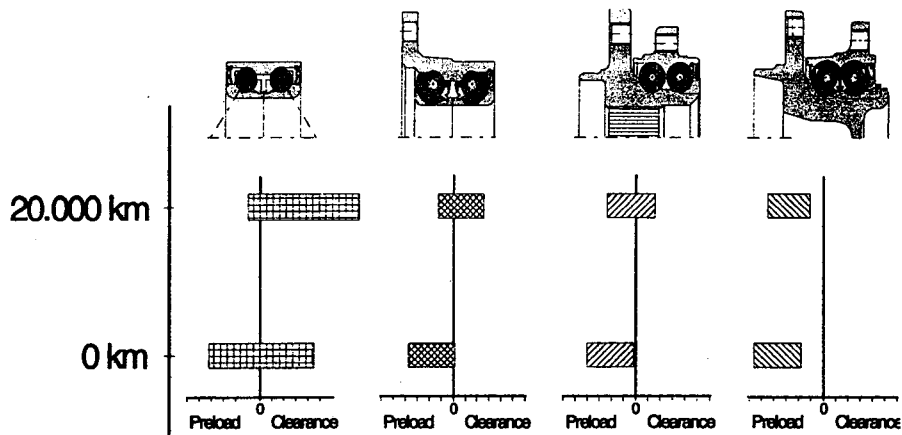
## HUB Unit Type



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## Preload/Clearance

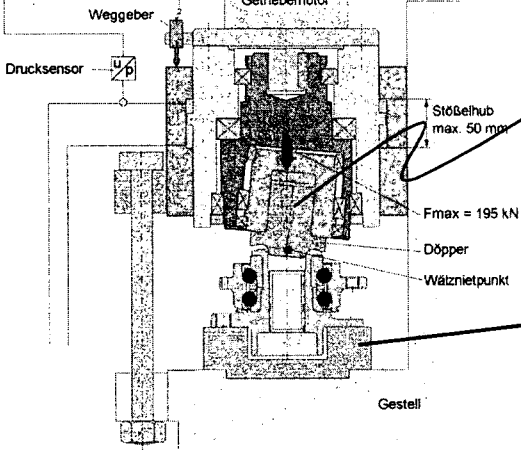
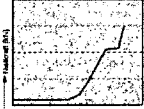


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# Orbital Forming Machine

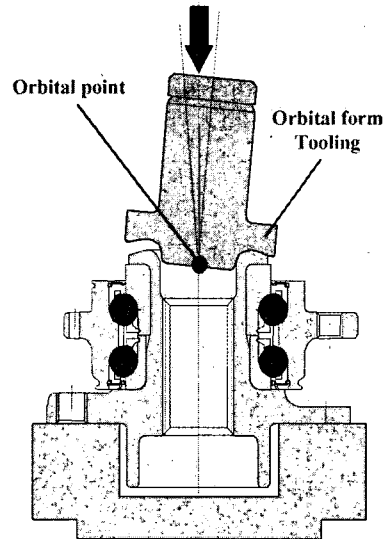
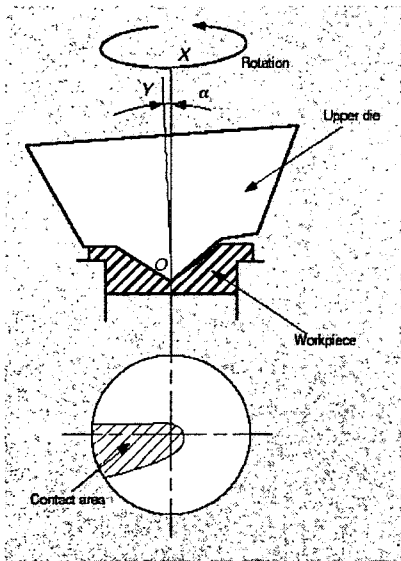
Kraft-Weg-Verlauf  
Tabelle in Handbuch mit Druckverlauf



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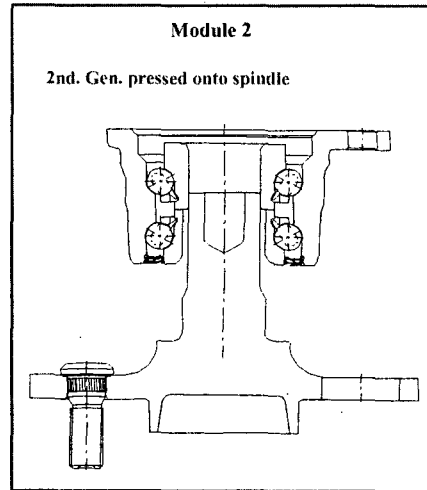
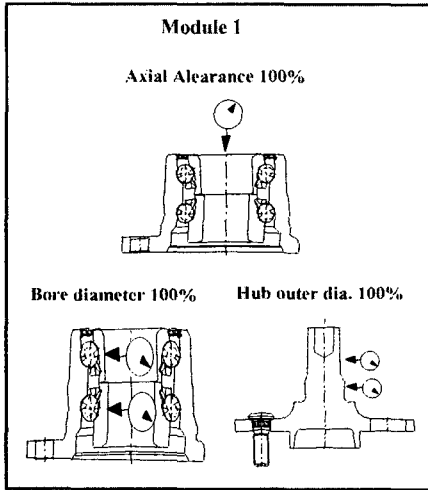
# Orbital Forming Process



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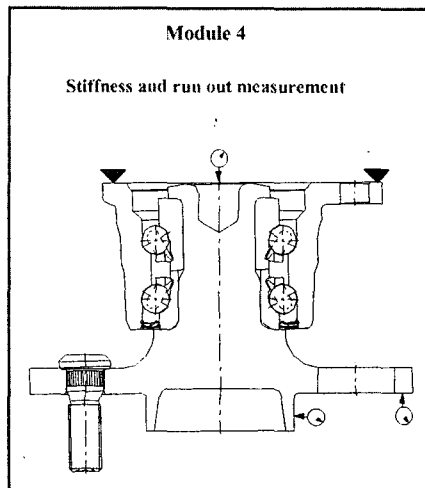
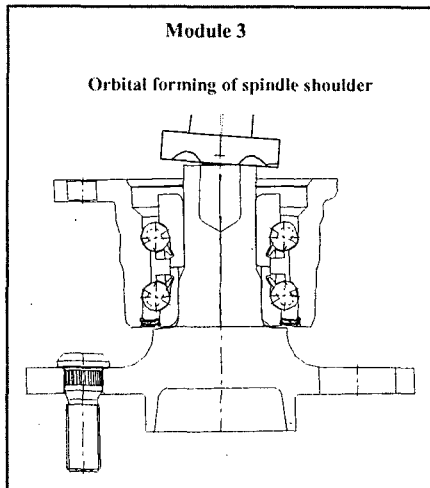
## Orbital Forming Technology



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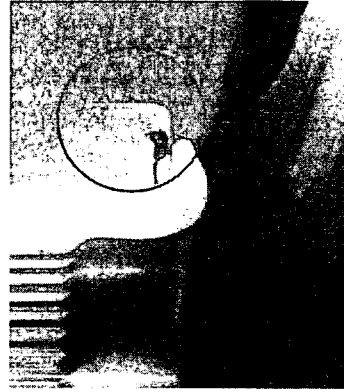
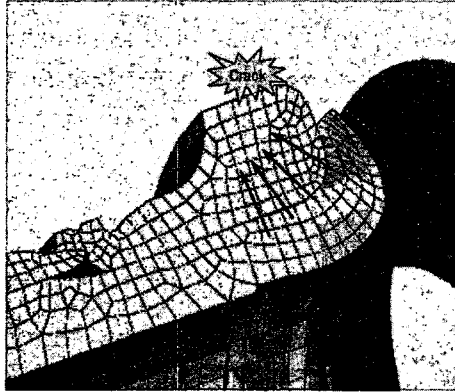
## Orbital Forming Technology



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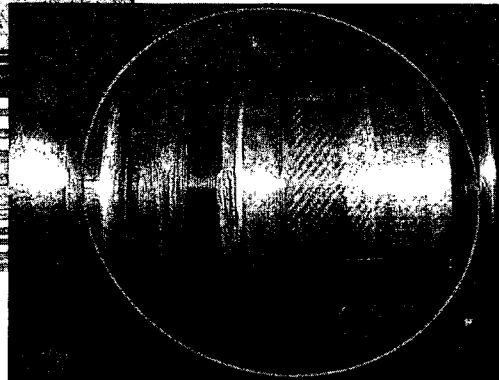
## Orbital Forming Problem



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## Orbital Forming Problem



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## Material Requirements for the Flanged Part

- **Material : SAE 1055, SAE 1070**
- **After the Forging of the Spindles : Controlled Cooling**
- **Hardness : 210 ~ 270 HB**
- **Compress Strength : 420 ~ 520 MPa**
- **Flange Strength : Ball Burnishing, Induction Hardening**
- **Austenite Grain Size :  $\geq 7$**
- **Deformation Behaviour :  $\geq 75\%$**

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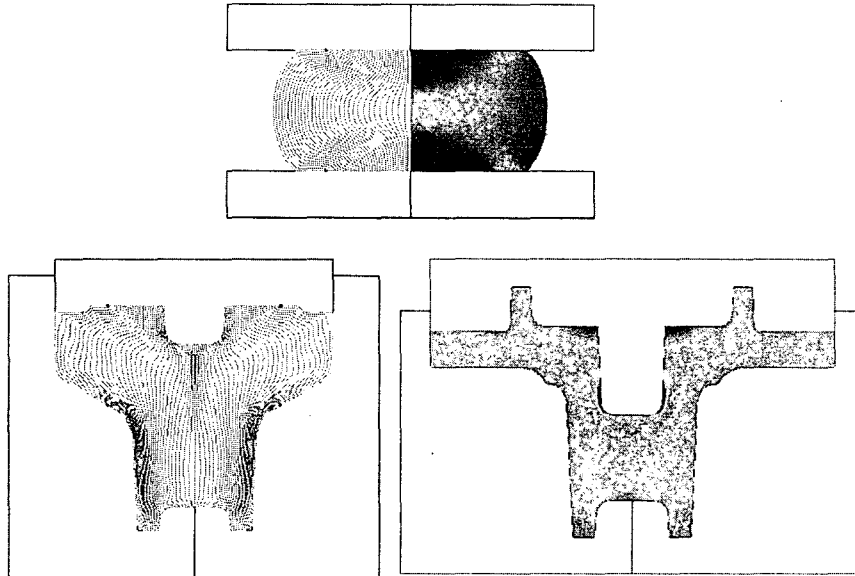
## Finite Element Analysis

- **Hot Forging Process for HUB Bearing**
- **Rigid-Plastic FEM : AFDEX 2D**
- **Analysis Conditions**
  - ☞ **Material : SAE 1055**
  - ☞ **Initial Temperature : 1100 °C**
  - ☞ **Average Forming Velocity : 300mm/s**
  - ☞ **Friction Coefficient :  $\mu = 0.3$**
  - ☞ **Flow Stress :  $\bar{\sigma} = 8.44\bar{\epsilon}^{0.148}$**
- **Press Process**
  - ☞ **Cutting → Induction Heating → Upsetting → Blocker →**  
**Finishing → Piercing → Controlled Cooling**

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## Analysis Result



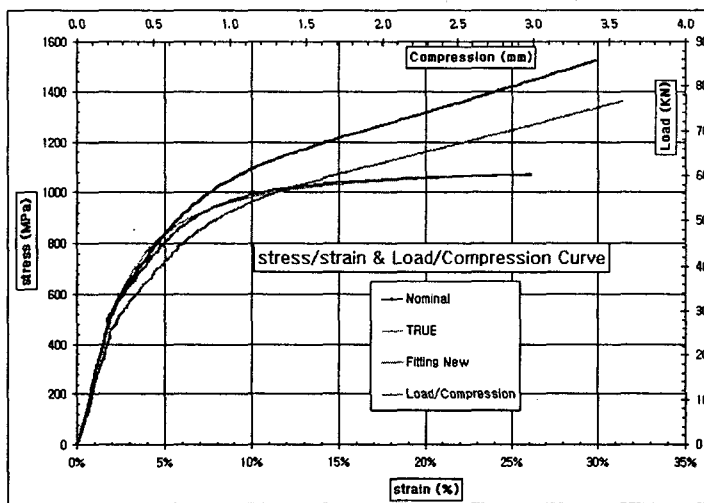
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## Compress Test Specimen

### Specimen Geometry

D = 8.0mm, H = 12.0mm



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## Finite Element Analysis

### ■ Cold Forging for HUB Bearing

### ■ Rigid-Plastic FEM : AFDEX 2D

### ■ Analysis Conditions

☞ Material : SAE 1055

☞ Average Forming Velocity : 1 mm/s

☞ Friction Coefficient :  $\mu = 0.05$

☞ Flow Stress :  $\bar{\sigma} = 520.0 \left(1 + \frac{\bar{\epsilon}}{0.001}\right)^{0.135}$

### ■ Purpose

☞ Tool and Flange Initial Shape Design

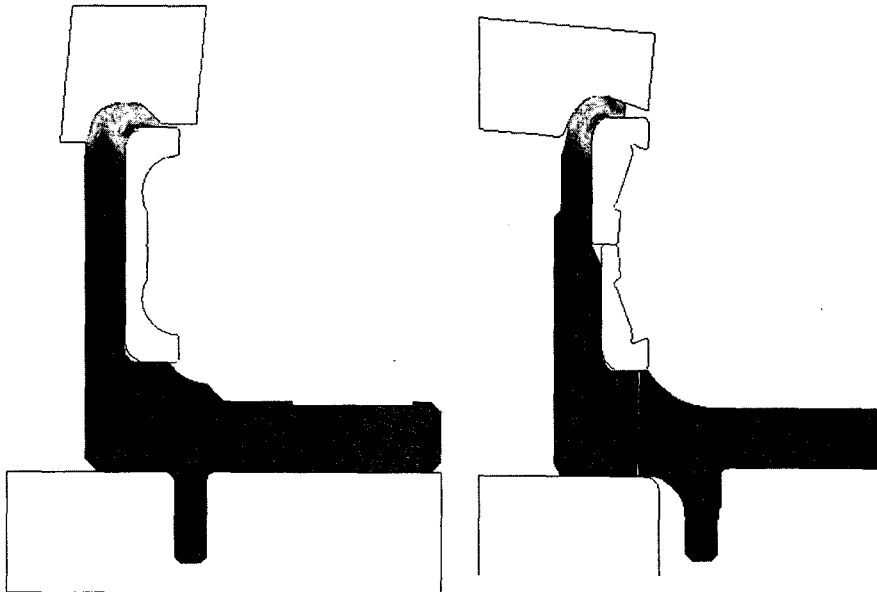
☞ Nodal Force Distribution

☞ Deformed Shape

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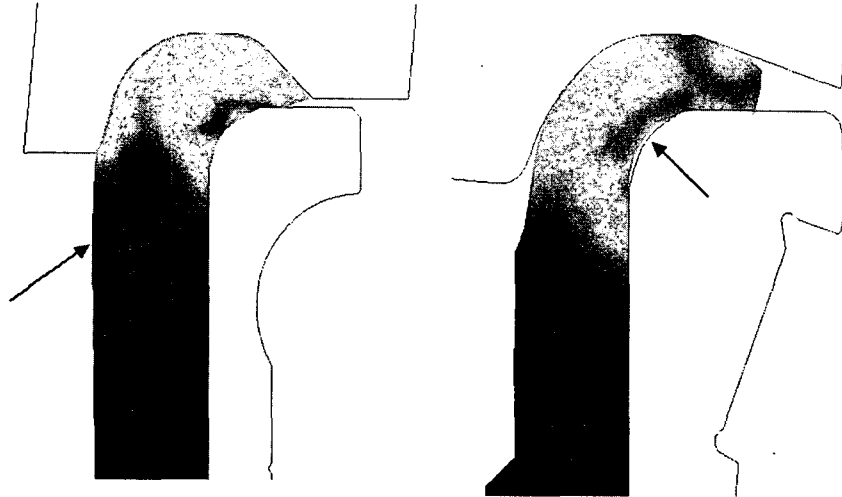
## Analysis Result – Deformed Shape



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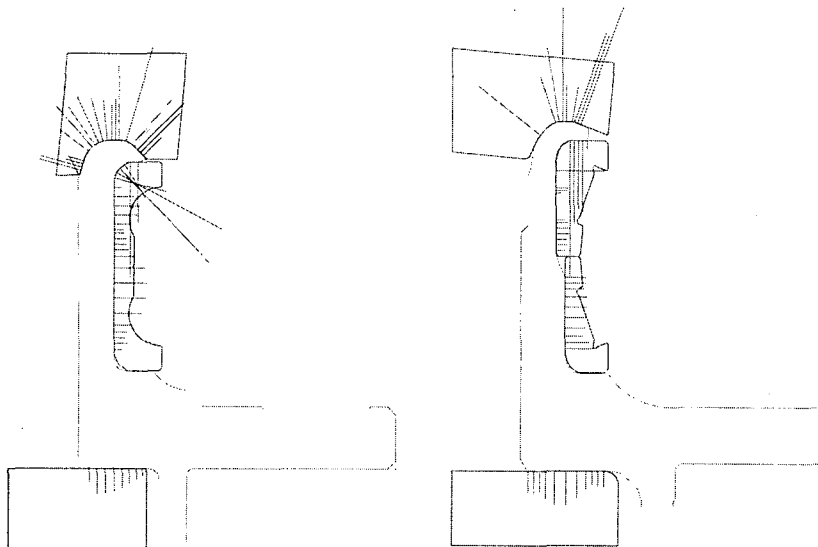
### Analysis Result – Deformed Shape



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### Analysis Result – Nodal Force



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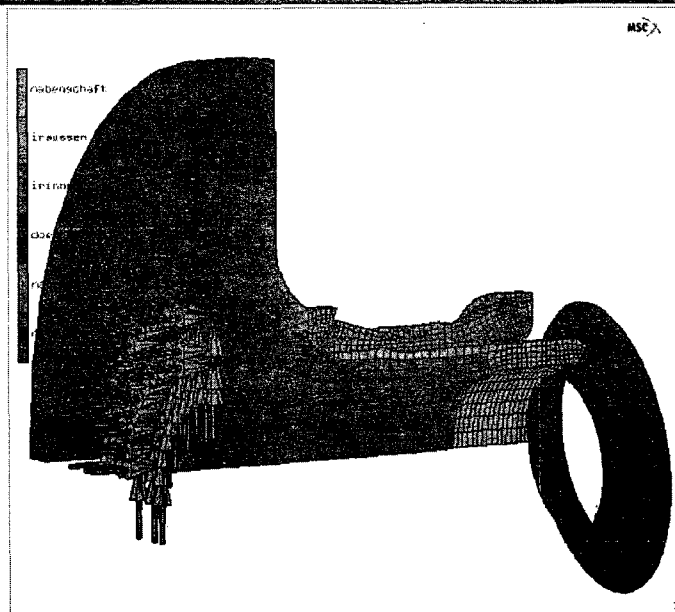
## Finite Element Analysis

- **Orbital Forming Process for Wheel Bearing**
- **Elastic-Plastic FEM : MARC**
- **Orbital Forming Parameters**
  - ☞ **Materials : SAE 1055, STB2**
  - ☞ **Axial Orbital Forming Force : 130 KN**
  - ☞ **Average Interference for the Inner Ring Seat: 40  $\mu\text{m}$**
  - ☞ **Rotation Speed : 5 revolutions per second**
- **Purpose**
  - ☞ **Determine the Tangential Stress on the Inner Ring Face**
  - ☞ **Inner Ring Clamping Force**
  - ☞ **Deformation for Inner Ring Shoulder, Lip and Raceways**

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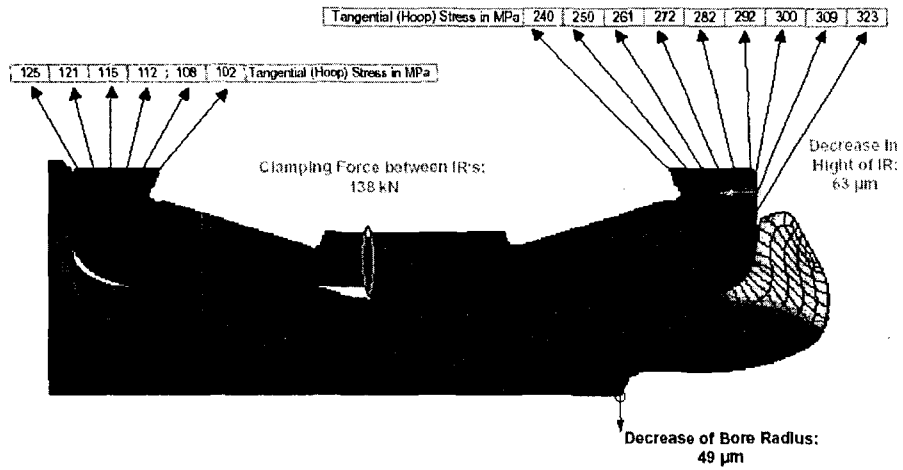
## Contact Bodies and Boundary Conditions



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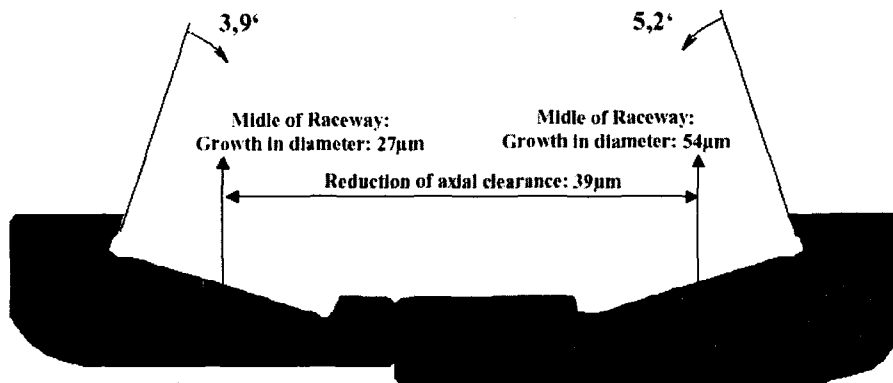
## Results after Orbital Forming



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## Deformations after Orbital Forming



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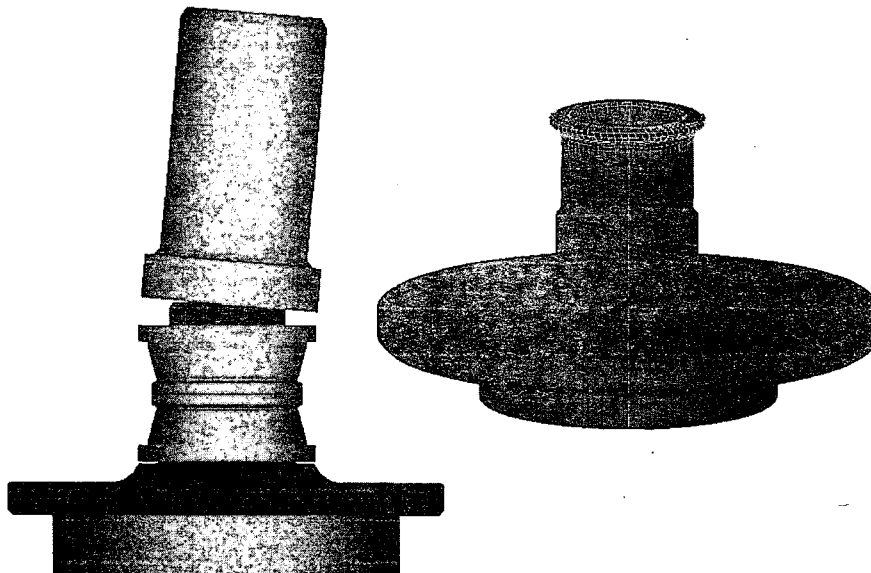
## Finite Element Analysis

- **Orbital Forming Process for Wheel Bearing**
- **Rigid-Plastic FEM : AFDEX 3D**
- **Orbital Forming Parameters**
  - ☞ **Material : SAE 1055**
  - ☞ **Forming Velocity : 0.5mm/rev.**
  - ☞ **Rotation Speed : 3.33 revolutions per second**
  - ☞ **Flow Stress :  $\bar{\sigma} = 520.0(1 + \frac{\bar{\epsilon}}{0.001})^{0.135}$**
- **Purpose**
  - ☞ **Deformed Shape**
  - ☞ **Forming Load**

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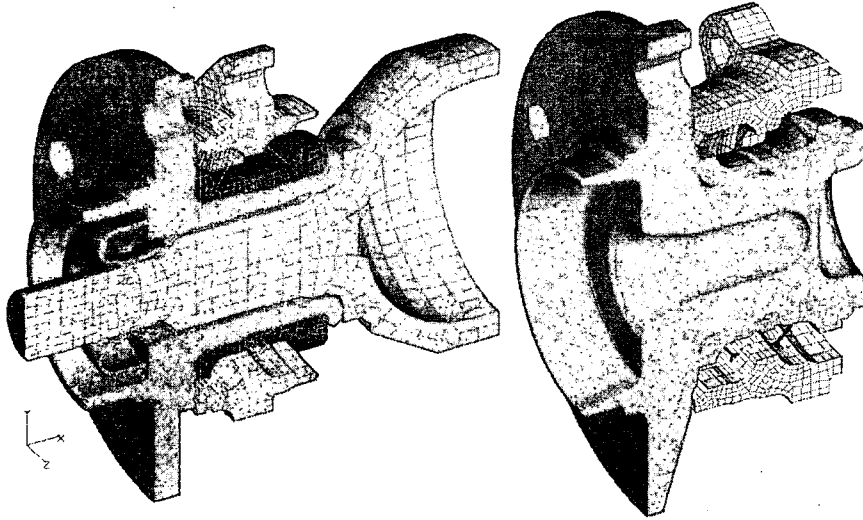
## Deformations after Orbital Forming



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## Structural Analysis



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## Conclusion

- **HUB Unit for Wheel Bearing**
- **Orbital Forming Process for Wheel Bearing**
  - ☞ Machine, Operation Know-How
  - ☞ Tool Design
  - ☞ Process Parameter
  - ☞ Inspection
- **Orbital Forming Analysis**
  - ☞ Elastic-Plastic Analysis(4~5days)
  - ☞ Rigid-Plastic Analysis → Elastic Analysis
  - ☞ Structural Analysis

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