

# Numerical Simulations of Forming Processes

Han Huétink



1 □

## Chair “Mechanics of Forming Processes”

### Mission:


- Develop advanced numerical methods for forming process simulations.
- Support the industry in using these methods.

**Research themes:** Material Modelling  
Numerical Procedures  
Optimisation



University of Twente  
The Netherlands

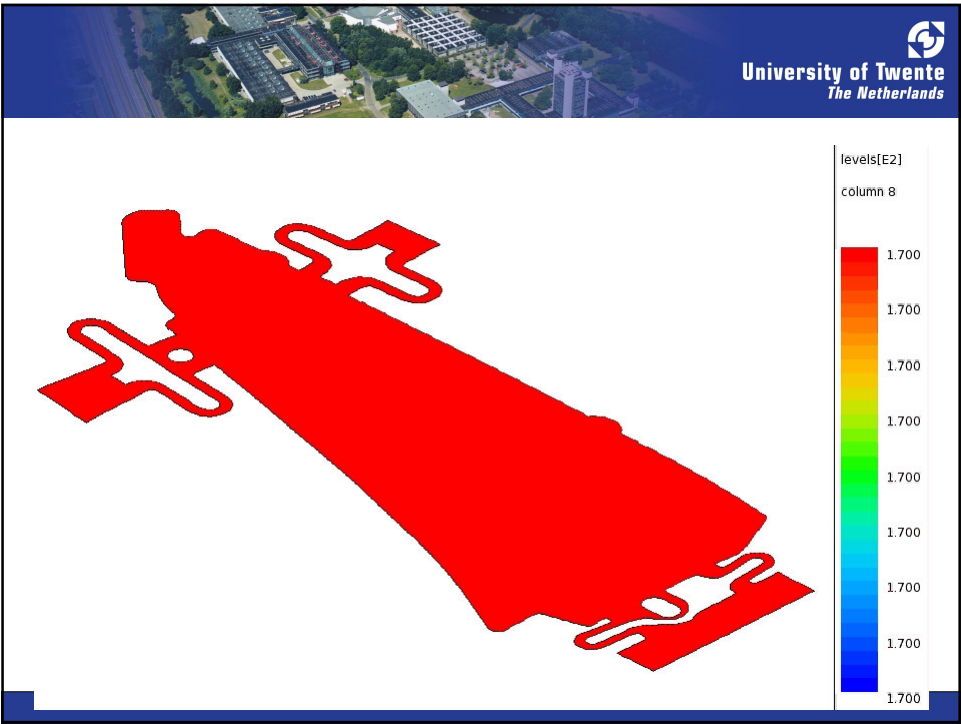
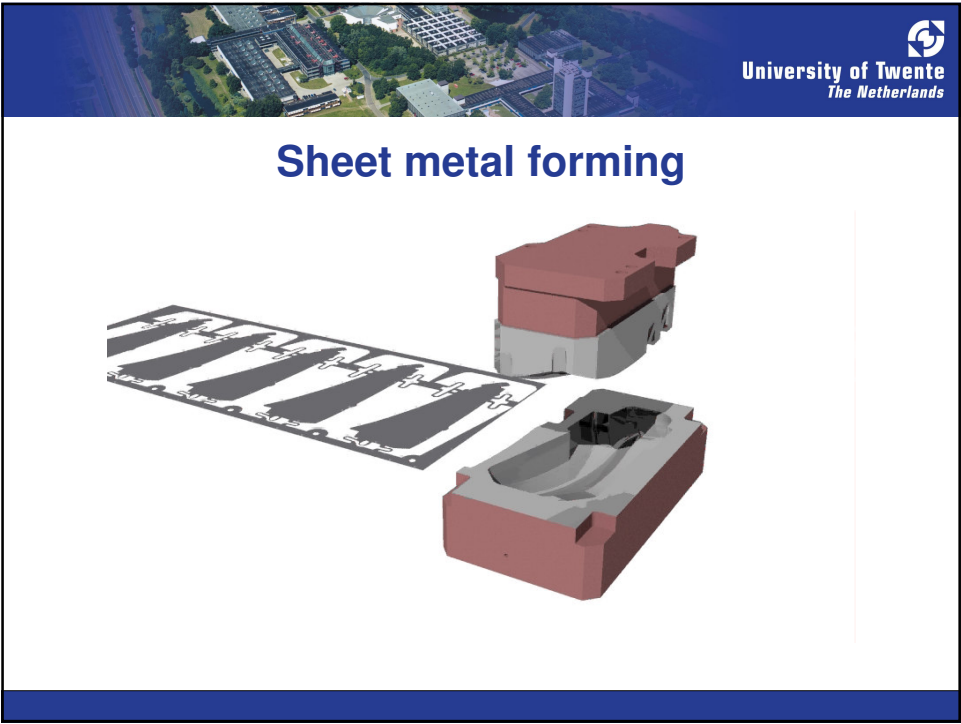
Staff	PhD researchers (2 vacancies)
<p>Han Huétink Ton van den Boogaard Bert Geijselaers Timo Meinders</p>	<p>Bert Koopman (BOAL) Semih Perdahcioglu (FOM) Pawel Owczarek (STW) Maarten van Riel (M2i) Corijn Snippe (FOM/Nikhef) Shihara Kurukuri (M2i) Ashraf Hadoush (M2i) Wissam Assaad (M2i) Wouter Quak (M2i) Muhammad S. Niazi (Nuffic) <b>2 Vacancies (M2i)</b></p>
<p>Wilko Emmens (Corus) Harm Wisselink (M2i)</p>	
	



University of Twente  
The Netherlands

### Research Area's

- Sheet metal forming (springback)
- Extrusion
- Material modeling
- **Biomechanics**



## Failure prediction



## Sheet metal forming

Springback: elastically driven change of product shape after load removal

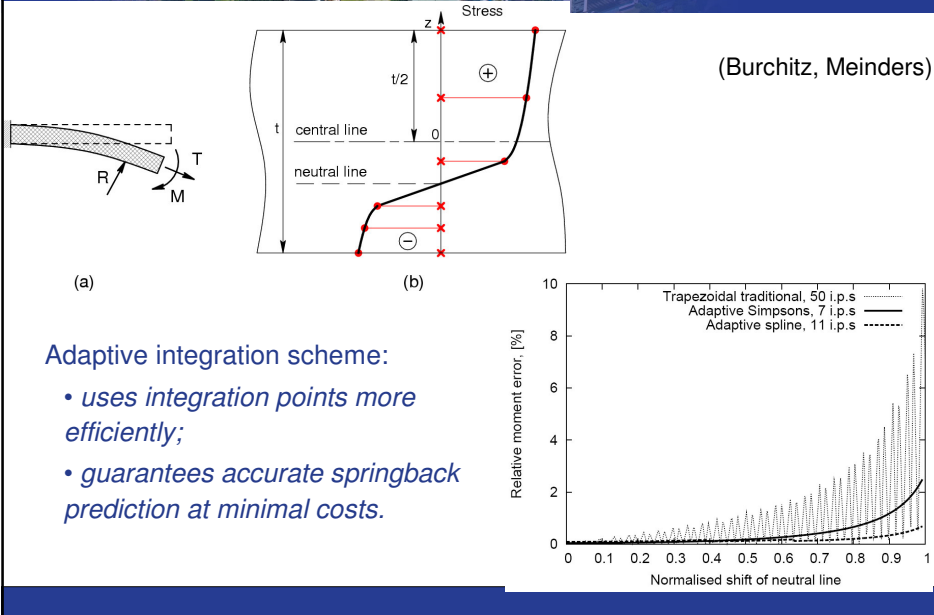
Reality: large deviation between desired product and sprung-back product

Springback compensation is needed

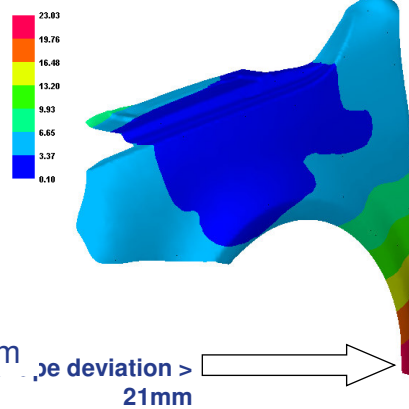
Costs for American car industry for springback related issues: \$50 million



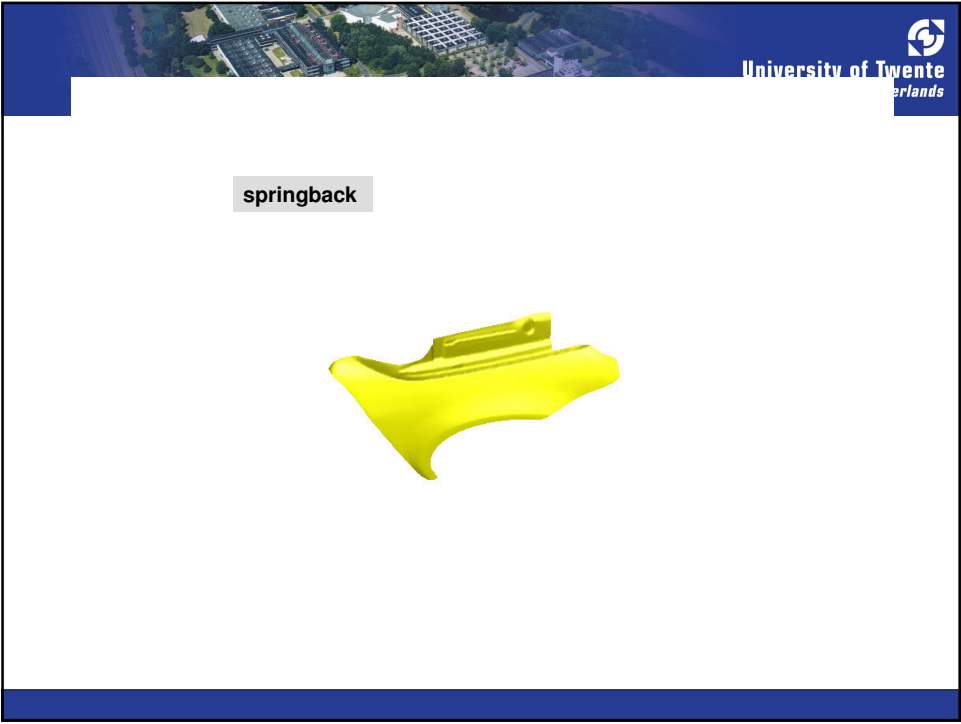
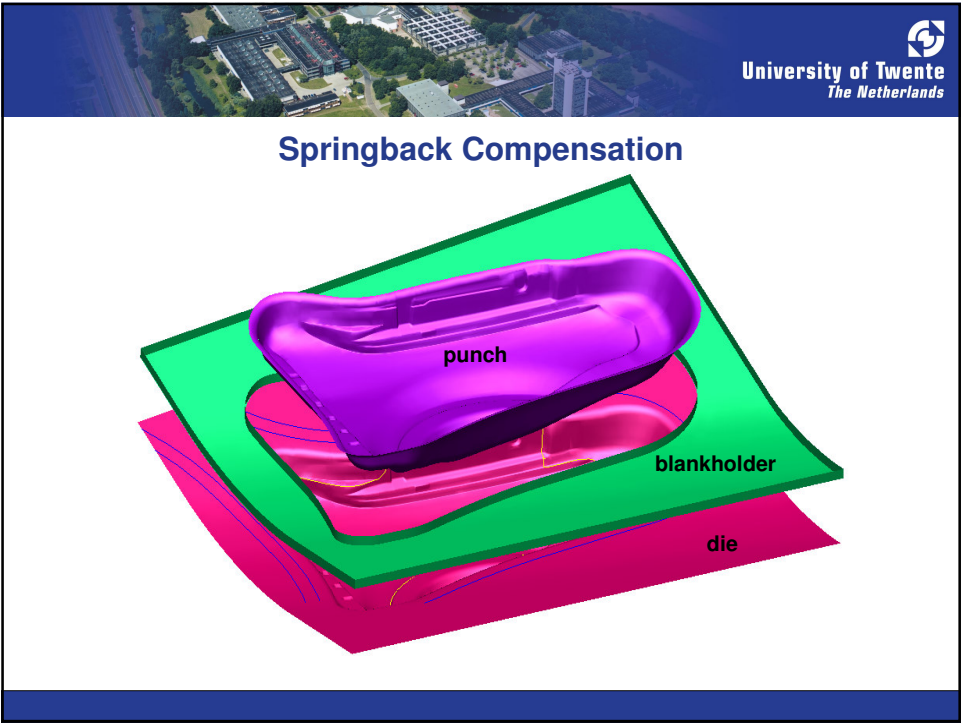
# Adaptive integration



# Springback Compensation

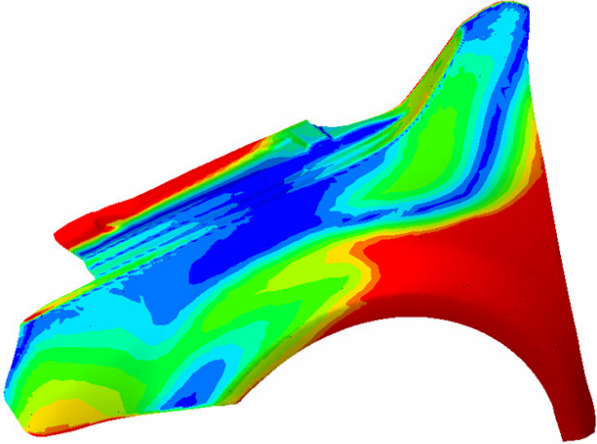


▪ goal develop an automatic springback compensation algorithm



University of Twente  
The Netherlands

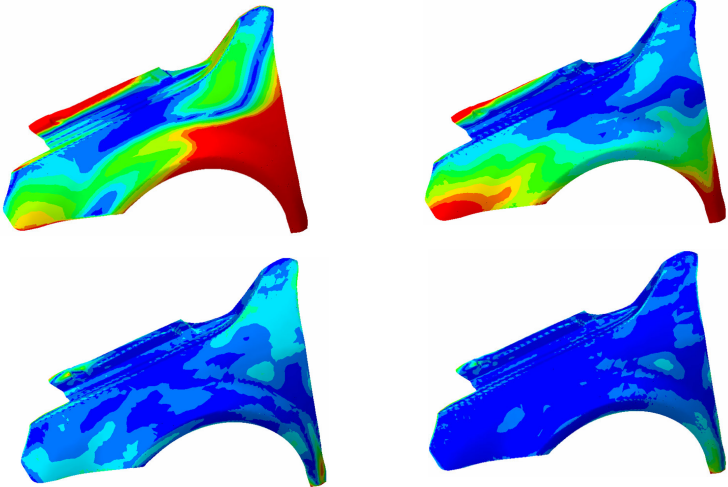
### Springback Compensation



A 3D surface plot of a curved mechanical part. The surface is color-coded, with a gradient from blue (low values) to red (high values). The highest values (red) are concentrated on the right side of the part, while the lowest values (blue) are on the left side. The part has a complex, curved geometry with a vertical flange on the right.

University of Twente  
The Netherlands

### Springback Compensation



Four 3D surface plots of the same curved mechanical part, arranged in a 2x2 grid. The top-left plot shows a color gradient from blue to red, similar to the first slide. The top-right plot shows a similar color gradient but with a different distribution. The bottom-left and bottom-right plots show the part with a predominantly blue color, indicating a different state or compensation level.

## Incremental sheet forming



## Incremental sheet forming

- Advantages
  - Relatively simple and cheap setup
  - Large deformation
  - Enhance the formability



Ideal for prototyping and  
small series production



- Disadvantage
  - The process is **SLOW**

First time right!!  
Need for simulations

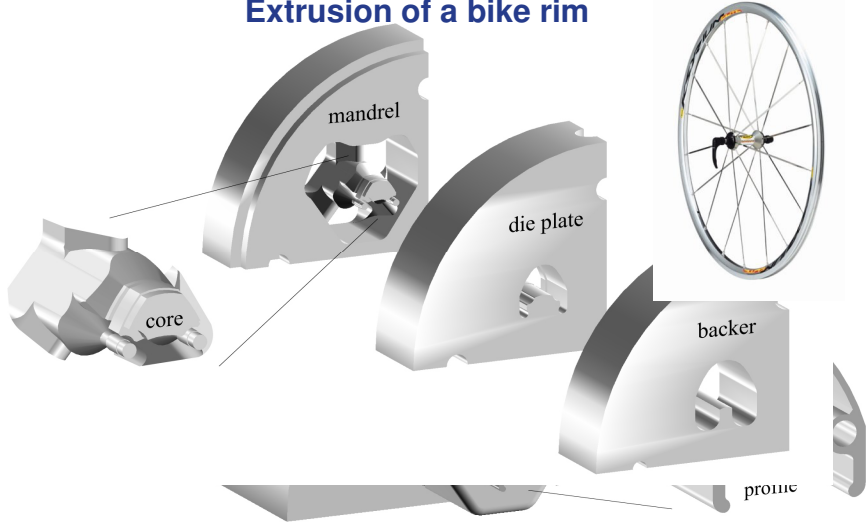
## Research Area's

- Sheet metal forming
- **Extrusion**
- Material modeling
- *Biomechanics*

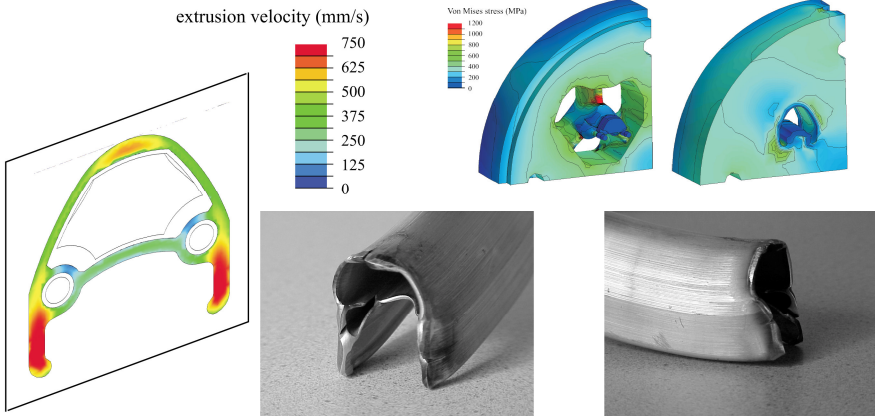




### Extrusion of a bike rim



### Extrusion of a bike rim



## Research Area's

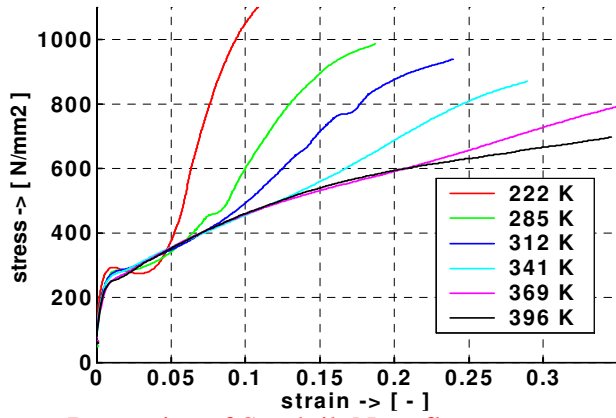
- Sheet metal forming
- Extrusion
- **Material modeling**
- *Biomechanics*

## Material Modeling

Trend in metal forming industry towards complex materials:

- High Strength Steels (HSS, HSLA)
- Dual Phase Steels
- Trip Steels
- Aluminum
- Superplastic Materials

**Simulation:** Need for accurate material models and material parameters

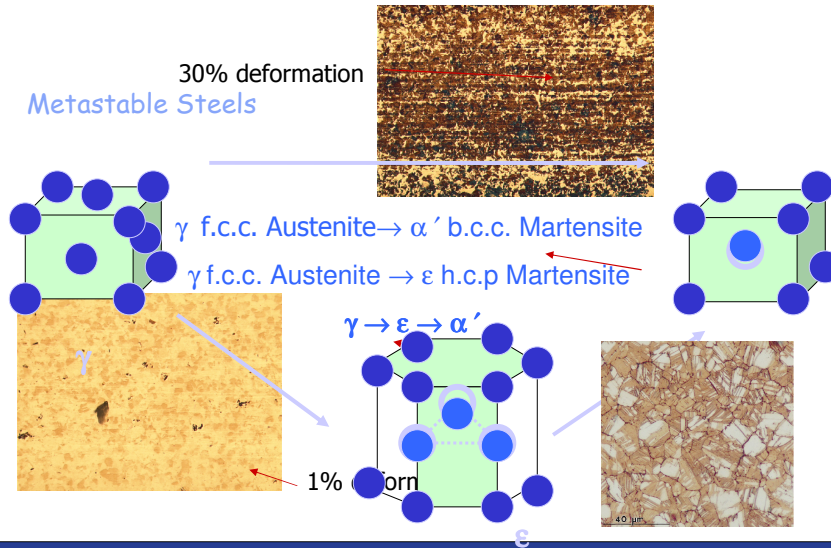


Properties of Sandvik Nanoflex



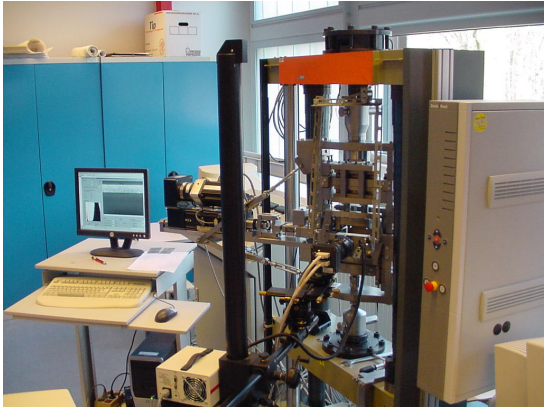
S. Perdahcioglu  
J. Post  
H. Geijselaers

30% deformation  
Metastable Steels

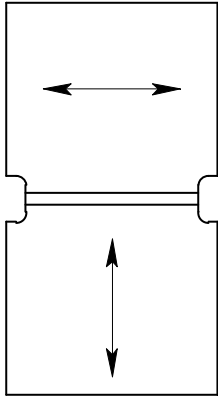




### Bi-axial test equipment



Test equipment



sample

### Optimisation

- **Modeling** Define objective function
- **Screening** Determine constraints, FEM (SAO) variables
- **Solving** Discrete variable (e.g. material)

Metal forming problem selection

**Modelling**

7 step methodology:

- Step 1: Select optimisation situation
- Step 2: Select necessary responses
- Step 3: Determine objective and implicit constraints
- Step 4: Quantify responses
- Step 5: Select design variables
- Step 6: Define design variable ranges
- Step 7: Identify explicit constraints

Optimisation ↓ model

Optimisation ↓ model

**Screening**

DOE      Pareto

Reduced ↓ model

Reduced ↓ model

**Solving**

SAO

```

    graph TD
      Model[Model] --> DOE[DOE]
      DOE --> RunPEM[Run FEM]
      RunPEM --> Optimize[Optimize]
      Optimize --> OK{OK?}
      OK -- No --> Model
      OK -- Yes --> Finished[Finished]
    
```


Optimal metal forming process


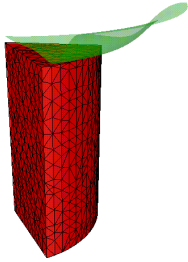
  
**University of Twente**  
*The Netherlands*

## Optimisation: Forging

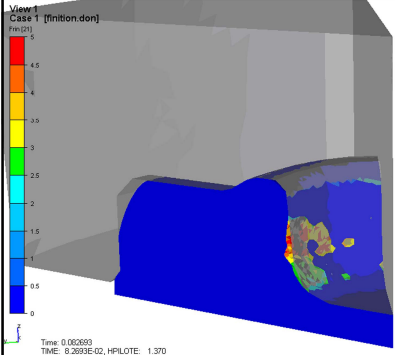





  
**University of Twente**  
*The Netherlands*

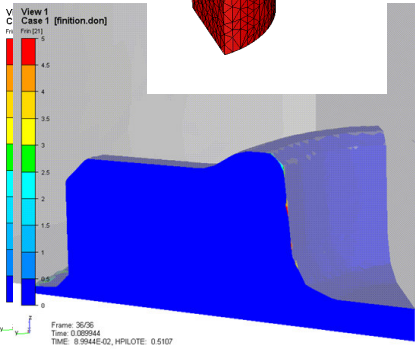



**View 1**  
Case 1 [fnitton.don]



Time: 0.00359  
TIME: 0.3933E+02, HPILOTE: 1.370

**View 1**  
C Case 1 [fnitton.don]

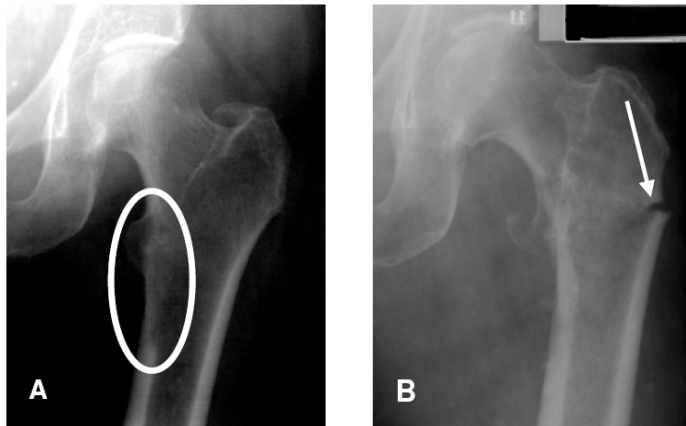


Frame: 3636  
Time: 0.1009944  
TIME: 0.3944E+02, HPILOTE: 0.5107

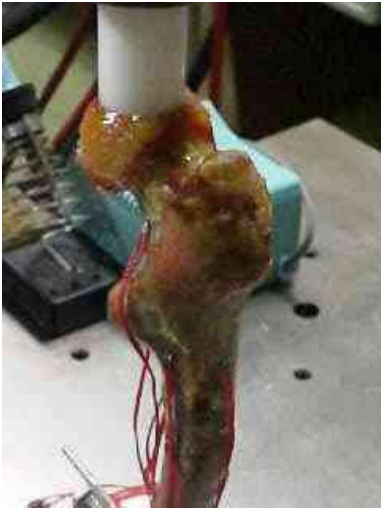
## Research Area's

- Sheet metal forming
- Extrusion
- Material modeling
- **Biomechanics**

## Bone Fracture



### Bone Fracture



### Bone Fracture

