



## Characteristics of Extrusion Shaping

### Importance of Our Work

Our researchers develop technology to facilitate cost-effective production of lightweight aluminum hydroformed components for automotive applications. At Pacific Northwest we

- understand the effect of alloy selection manufacturing method, and heat treatment condition on the process of tubular hydroforming
- develop failure criteria and integrate the criteria with finite element analysis
- investigate the effects of prebending or other processes preceding the hydroforming process.

### Project Benefits

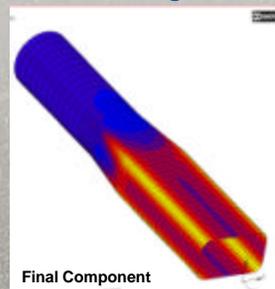
- Reduced weight for high fuel efficiency
- Reduces cost by reducing part count and assembly time
- Improved structural performance

### Project Participants

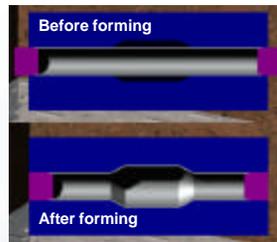
Pacific Northwest National Laboratory  
Alcoa Inc.

### Commercial Hydroforming

Trials conducted at Alcoa on commercial hydroforming equipment to investigate and validate forming limits.



### Hydroforming Process Schematic



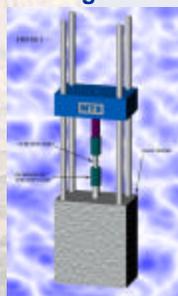
### Lightweight Structural Aluminum Hydroformed Components

Hydroforming is often used in conjunction with bending operations.



### Laboratory Free Hydroforming of Aluminum Extrusions

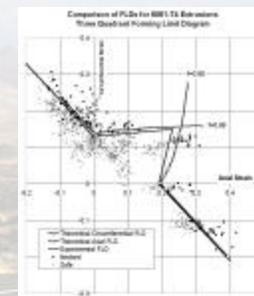
The limits of material formability during hydroforming stand as a key question for aluminum alloys. The formability was investigated for several alloys and heat treatments. The figures below represent experiments and results of the formability of typical materials. In addition to the experimental forming limits, theoretical forming limits and modes of buckling under axial load are shown.



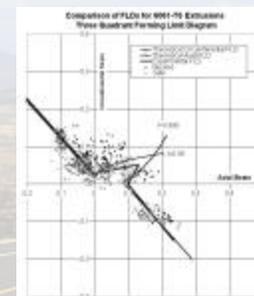
Laboratory hydroforming apparatus



Tubes tested under laboratory conditions



Forming limits of 6061-T4 during laboratory testing



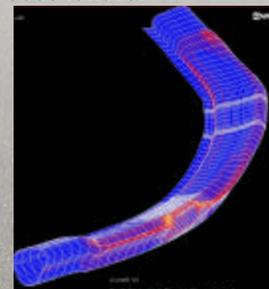
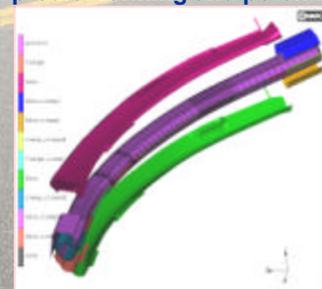
Forming limits of 6061-T6 during laboratory testing



Wrinkling under excessive axial load testing

### Numerical Modeling of Hydroforming

Extensive sequential process models are used to predict forming and potential process failure.



### Laboratory Hydroforming with Dies

Dies introduced limit buckling and extend forming.

