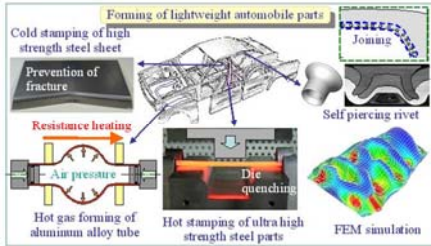


## JSTP International Prize

### Software and hardware approaches for development of forging and other forming processes: Finite element method and new processes

Toyohashi University of Technology  
Ken-ichiro Mori



## Contents

1. Software approach: FEM, knowledge engineering, microscopic
2. Hardware approach: development of new forming processes
3. Heating: hot stamping of ultra-high strength steel parts
4. Vibration: pulsating forging and hydroforming
5. Analysis of research works by scientific database

## History of research works

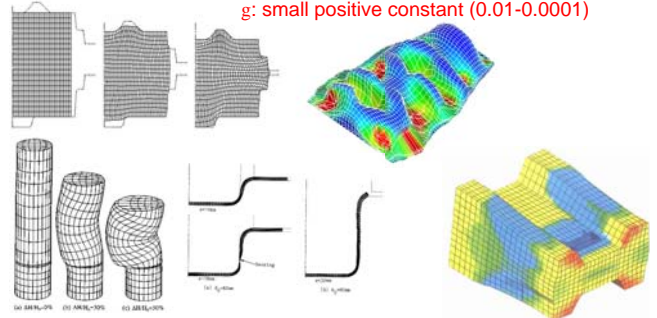
- Software: rapid development of computers
- 1980
    - Formulation of rigid-plastic finite element method
    - Application to forging, rolling, extrusion, drawing, sheet metal forming, powder forming, etc.
  - 1990
    - Knowledge engineering: expert system, fuzzy control, neural network, GA
    - Microscopic analysis: microscopic FEM, DEM, Monte Carlo method
  - 2000
    - Stamping of high strength steel sheets, hot stamping
  - 2010
    - Joining by plastic deformation: self-pierce riveting, mechanical clinching
    - Pulsating forging and hydroforming
    - Plate forging for thickening and thinning
    - Stamping of titanium, magnesium, aluminium sheets
- Hardware: automobile lightweighting  
1997: Toyohashi University of Technology

## Finite element simulation

Rigid-plastic FEM for slightly compressible material

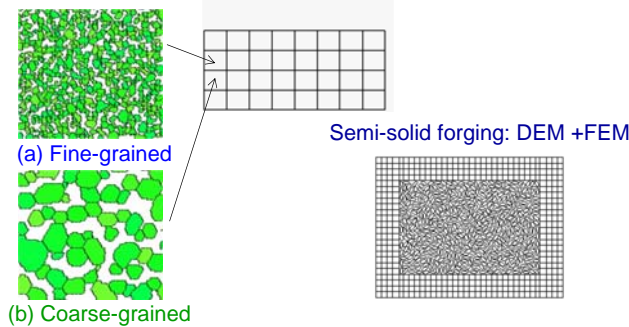
$$\bar{\sigma} = \frac{1}{2} \{ (\sigma_x - \sigma_y)^2 + (\sigma_x - \sigma_z)^2 + (\sigma_y - \sigma_z)^2 + 6(\tau_{xy}^2 + \tau_{yz}^2 + \tau_{zx}^2) \} + g\sigma_m^2$$

$g$ : small positive constant (0.01-0.0001)



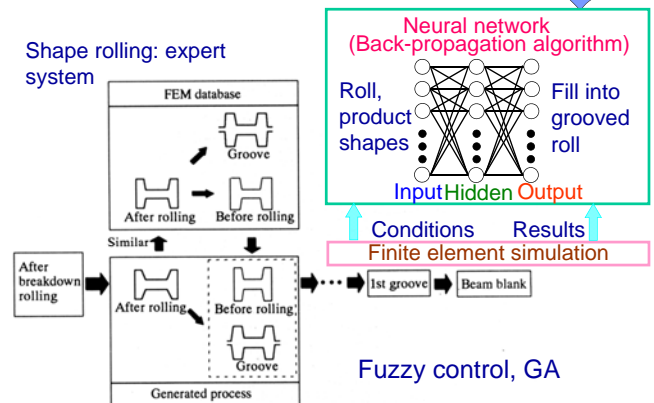
## Microscopic analysis

Sintering: Monte Carlo method + FEM



## Knowledge engineering

Shape rolling: expert system

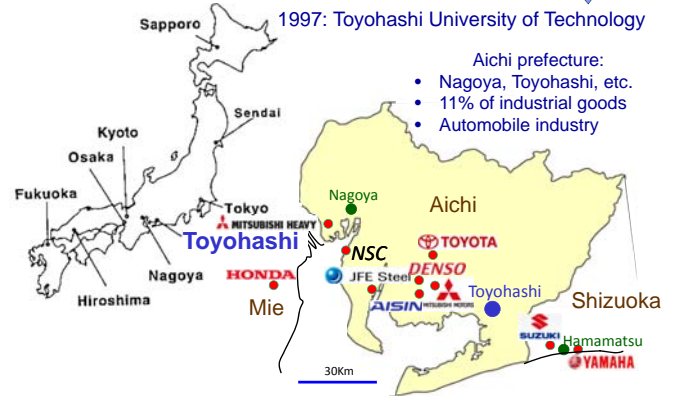


## Contents

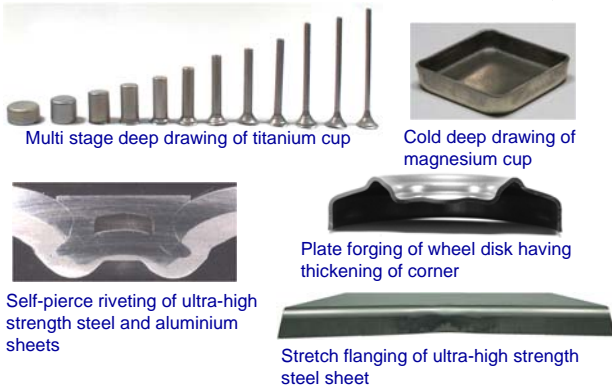


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## Industries near Toyohashi



## New forming processes



## Contents

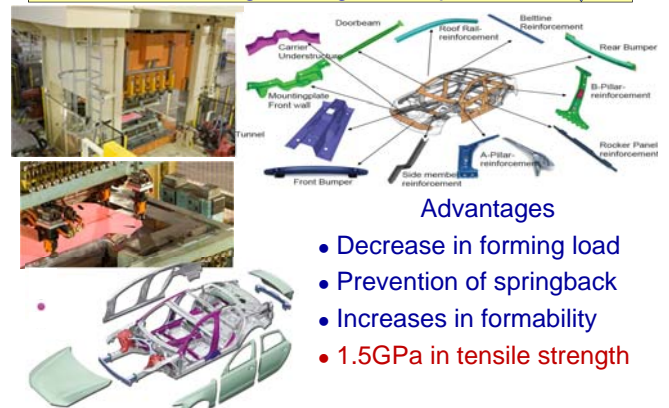


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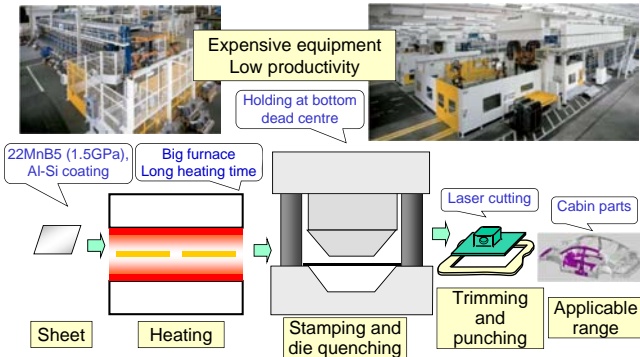
## Problems in stamping of high strength steel sheets



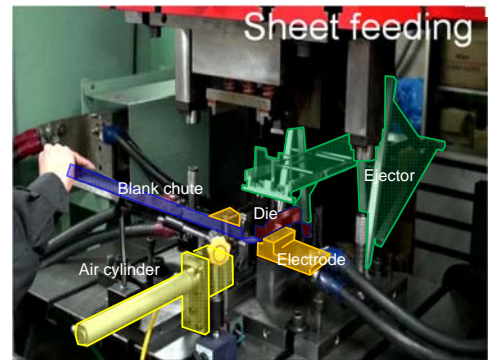
## Hot stamping of ultra-high strength steel parts



### Problems in 1st generation hot stamping processes



### Repeated resistance heating hot stamping

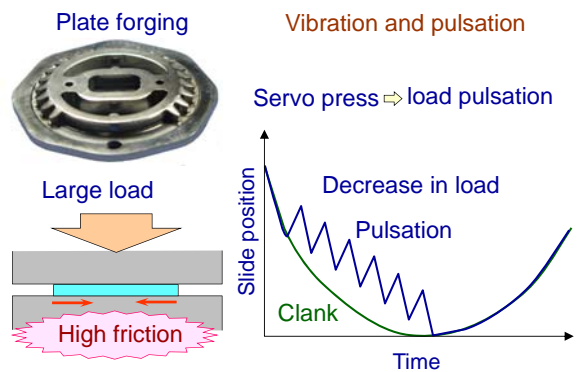


Transferring → Resistance heating, → Products stamping + die quenching

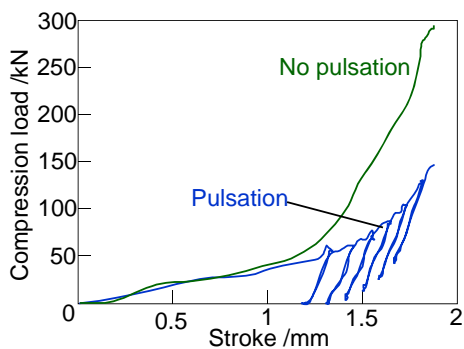
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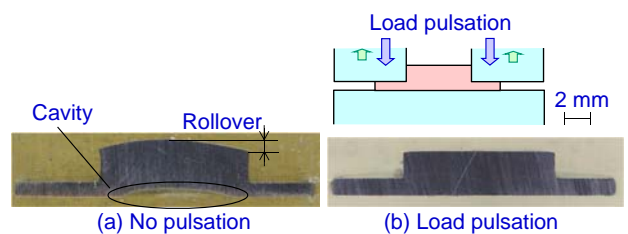
### Reduction of friction in plate forging by load pulsation



### Variations of compressive load with stroke with and without load pulsation



### Plate forging of stainless steel SUS403 plate



Reduction in thickness: 63%

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## Research works



### Forming Technology

1. Input: materials such as metals, plastics, ceramics
2. Processing: forming method, tools, lubricants
3. Output: products such as high strength, lightweight, functional properties

### Research works

1. Input: information and knowledge
2. Processing: idea and thinking
3. Output: effects on engineering and industrial products, papers

## Citation of papers in scientific database



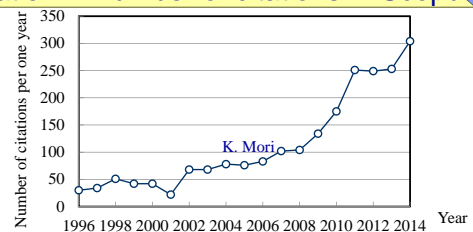
Scientific paper database: Web of Science, Scopus, Google Scholar, Science Direct

Citations: number cited in references of other papers

Impact factor: number of citations for journal, evaluation of journal and not individual papers

[Papers of Mori cited in Scopus](#)

## Variation in number of citations in Scopus



**Hot stamping:** "128", Mori, K., Maki, S., Tanaka, Y., Warm and hot stamping of ultra high tensile strength steel sheets using resistance heating, CIRP Annals - Manufacturing Technology, (2005), "49", Mori, K., Saito, S., Maki, S., Warm and hot punching of ultra high strength steel, CIRP Annals - Manufacturing Technology, (2008)

**High strength steel sheets:** "61", Mori, K., Akita, K., Abe, Y., Springback behaviour in bending of ultra-high-strength steel sheets using CNC servo press, International Journal of Machine Tools and Manufacture, (2007)

**Joining by plastic deformation:** "58", Abe, Y., Kato, T., Mori, K., Joinability of aluminium alloy and mild steel sheets by self piercing rivet, Journal of Materials Processing Technology, (2006), "41", Abe, Y., Kato, T., Mori, K., Self-piercing riveting of high tensile strength steel and aluminium alloy sheets using conventional rivet and die, Journal of Materials Processing, (2009)

**Servo press:** "43", Osakada, K., Mori, K., Altan, T., Groche, P., Mechanical servo press technology for metal forming, CIRP Annals - Manufacturing Technology, (2011)

## Advices for teachers



1. Change in situation.
2. Write English journal papers.

Thank you very much

