1. Engineering education system in Japanese universities
2. Laboratory education
3. Publication of papers
4. Toyohashi University of Technology
5. Frontier Forming System Laboratory

**Education system in Japan**

- Doctor: 16,000
- Master: 77,000
- University: 525,000
- Engineering: 15%, Science: 3%, Agriculture: 3%

**Japanese university**

<table>
<thead>
<tr>
<th></th>
<th>Number of universities</th>
<th>Number of students</th>
<th>Number of postgraduate students</th>
</tr>
</thead>
<tbody>
<tr>
<td>National</td>
<td>86</td>
<td>620,000</td>
<td>154,000</td>
</tr>
<tr>
<td>Prefectural</td>
<td>95</td>
<td>140,000</td>
<td>14,000</td>
</tr>
<tr>
<td>Private</td>
<td>599</td>
<td>2,130,000</td>
<td>94,000</td>
</tr>
<tr>
<td>Total</td>
<td>780</td>
<td>2,890,000</td>
<td>263,000</td>
</tr>
</tbody>
</table>

National: Tokyo, Kyoto, Osaka, Tohoku, Nagoya, Kyushu
Private: Waseda, Keio

National universities are leading for education of high-level engineers: cheaper tuition fee, high-level professors, wealthy facilities.

**Development of Japanese industry**

- Faculty of Engineering: 3 times larger
- Sufficient engineers
- Superior readers
- No conscription: 22-23 years old
- Diploma: 89%

**GDP in Japan /$**

- Rapid growth
- University entrance
  - Japan: 55% (2007)
  - Russia: 25% (2005)
- Crude steel production /million ton

**Formation processes**
Engineering education in laboratory

Staff: 1 professor, 1 associate professor or lecturer, 1 research associate

Bachelor: 4 years
1-3rd years: class, teaching
4th year: belonging to laboratories (research and not practice)

Master: 2 years, many
3 year research work: good training of engineers, 24-25 years old

Doctor: 3 years, few, 27-30 years old course, paper

Research work in laboratory

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Presentation
Research policy

Entry: to decide research topics
   Originality, background, co-operation, target

Work: students, supervising, judgment,
   Good results, new finding

Exit: publishing of papers
   Research impact

Publication and database of research papers

Proceedings (conference) papers:
   Easy reviewing, not high quality
   Knowledge exchange

Journal papers:
   Hard reviewing, authorized, high quality,
   high citation

International: English, Internet search (from 2000)

Scopus, web of knowledge: journals and proceedings

Science Direct: Elsevier, only journals (impact factor), biggest database

Hot to write journal papers

Readers feels interesting

Introduction:
   Background, initiation, importance,
   references of journal papers

Results:
   High quality figures than text (1st and 2nd figures): not lengthy

Balance: originality and results

Checking, polishing, long time
   Fighting

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Toyohashi University of Technology

Population: 380,000
Area: 630 km²
Industries near Toyohashi

Aichi prefecture:
- Nagoya, Toyohashi, etc.
- 11.4% of industrial goods
- Automobile industry

Toyohashi University of Technology

National university
Found in 1976
Number of students: 2,194
International: 184
Academic staff: 199
5 departments, 1 research institute and 6 research centers
Area: 355,606 m²

Feature in Toyohashi University of Technology

- Doctor: 16,000
- Master: 77,000
- University: 525,000
- Kosen (College of Technology): 11,000
- High school: 1,170,000
- Junior high school: 1,200,000
- Elementary school: 6 years

Number of students

- Undergraduate course: 1,146 (63)
- Master course: 917 (70)
- Doctoral course: 119 (40)
- Research students, other non-degree students: 12 (11)
- Total: 2,194 (84)

( ): Number of international students

Foreign students

<table>
<thead>
<tr>
<th>Country</th>
<th>Number</th>
<th>Country</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia</td>
<td></td>
<td>South America</td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>2</td>
<td>Colombia</td>
<td>2</td>
</tr>
<tr>
<td>Indonesia</td>
<td>24</td>
<td>Brazil</td>
<td>1</td>
</tr>
<tr>
<td>Vietnam</td>
<td>24</td>
<td>Europe</td>
<td></td>
</tr>
<tr>
<td>Cambodia</td>
<td>1</td>
<td>Uzbekistan</td>
<td>1</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>2</td>
<td>Albania</td>
<td>1</td>
</tr>
<tr>
<td>Thailand</td>
<td>1</td>
<td>Bosnia and Herzegovina</td>
<td>1</td>
</tr>
<tr>
<td>Korea</td>
<td>9</td>
<td>Middle East</td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>21</td>
<td>Palestinian Territories</td>
<td>1</td>
</tr>
<tr>
<td>Nepal</td>
<td>1</td>
<td>Afghanistan</td>
<td>2</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>9</td>
<td>Africa</td>
<td></td>
</tr>
<tr>
<td>Malaysia</td>
<td>54</td>
<td>Egypt</td>
<td>1</td>
</tr>
<tr>
<td>Myanmar</td>
<td>5</td>
<td>Morocco</td>
<td>1</td>
</tr>
<tr>
<td>Mongolia</td>
<td>6</td>
<td>Zimbabwe</td>
<td>1</td>
</tr>
<tr>
<td>Laos</td>
<td>10</td>
<td>Guinea</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Algeria</td>
<td>1</td>
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<tr>
<td></td>
<td></td>
<td>Tanzania</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>184</td>
</tr>
</tbody>
</table>

Robot contest
**Departments**

**Mechanical Engineering**
- Mechanical Systems Design Course
- Material and Manufacturing Course
- System Control and Robotics Course
- Environment and Energy Course

**Electrical & Electronic Information Engineering**
- Electronic Materials Course
- Electrical Systems Course
- Integrated Electronics Course
- Information and Communication Systems Course

**Computer Science & Engineering**
- Computer and Information Science Course
- Information and Systems Science Course

**Environmental & Life Sciences**
- Sustainable Development Course
- Life and Materials Science Course

**Architecture & Civil Engineering**
- Architecture and Building Science Course
- Civil and Environmental Engineering Course

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**Laboratories for Department of Mechanical Engineering**

**Mechanical Systems Design Course**
- Material and Structural Mechanics Laboratory
- Machine Dynamics Laboratory
- Frontier Forming System Laboratory
- MEMS/NEMS Processing Laboratory

**System Control and Robotics Course**
- Robotics and Mechatronics Laboratory
- Instrumentation Systems Laboratory
- System and Control Engineering Laboratory
- Industrial Systems Engineering Laboratory

**Material and Manufacturing Course**
- Materials Function Control Laboratory
- Laboratory for Materials Strength & Characterization in 3D/4D
- Thin Film Laboratory
- Interface and Surface Fabrication Laboratory

**Environment and Energy Course**
- Energy Conversion Engineering Laboratory
- Thermo-Fluid Engineering Laboratory
- Natural Energy Conversion Science Laboratory
- Energy Conservation Engineering Laboratory

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**Frontier Forming System Laboratory**

Novel Processes: high strength steel, aluminium alloy, titanium alloy, magnesium alloy

- Forming processes using plastic deformation
  - Rolling
  - Sheet metal forming
  - Drawing
  - Extrusion
  - Sheet metal forming
  - Forging
  - Forging

---

**Members**

**Staff**
- Professor
- Associate professor
- Research associate

**Student**
- Doctor: 4
- Master, 2nd year: 8
- Master, 1st year: 8
- Undergraduate 4th year: 9

3+29=32
1) Development of forming processes of lightweight metals
   • 1 shot hot stamping of ultra-high strength steel parts
   • Improvement of formability in hot stamping
   • Warm and hot punching of ultra-high strength steel sheets using resistance heating
   • Hot stamping of titanium alloy sheets
   • Improvement of springback in bending of ultra-high strength steel sheets using servo press
   • Prevention of fracture in stretch flanging of ultra-high strength steel sheets
   • Prevention of wrinkling in shrinkage flanging of ultra-high strength steel sheets
   • Improvement of quality of sheared edge in punching of ultra-high strength steel sheets
   • Punching process including thickening of hole edge of ultra-high strength steel sheet
   • Self-pierce riveting of high strength steel and aluminium alloy sheets
   • Prevention of seizure in deep drawing and ironing of aluminium alloy and stainless steel cups
   • Local thickening of steel wheel disk
   • Hot forging of aluminium alloy billet having die quenching
   • Cold deep drawing of magnesium alloy sheet

2) Development of forming processes of lightweight parts
   • Gas forming of aluminium alloy and quenchable steel tubes using resistance heating
   • Forming of tailor blanks having local thickening for stamping
   • Improvement of formability by oscillation of internal pressure in pulsating hydroforming of tube

3) Development of new forming processes
   • Automatic re-lubrication in forging of plates by load oscillation
   • Consolidation of iron powder by extrusion
   • In-situ measurement during stamping using borescope

### Specific strength for various sheet metals

<table>
<thead>
<tr>
<th>Sheet</th>
<th>Tensile strength</th>
<th>Specific gravity</th>
<th>Strength-to-specific gravity ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultra high strength steel</td>
<td>980 - 1470MPa</td>
<td>7.8</td>
<td>126 - 188MPa</td>
</tr>
<tr>
<td>High strength steel</td>
<td>490 - 790MPa</td>
<td>7.8</td>
<td>63-101MPa</td>
</tr>
<tr>
<td>Mild steel SPCC</td>
<td>340MPa</td>
<td>7.8</td>
<td>44MPa</td>
</tr>
<tr>
<td>Aluminium alloy A6061(T6)</td>
<td>310MPa</td>
<td>2.7</td>
<td>115MPa</td>
</tr>
</tbody>
</table>

### Problems in stamping of high strength steel sheets

- Large springback
- Seizure
- Fracture
- Small ductility

### Deformation behaviour in V-shaped bending

(a) SPCC  
(b) SPFC980Y

\[
v=24\text{mm/s}, f=0\%, T=0.5s\]

3 times slower
Effects of bottoming and holding time at bottom dead centre for SPFC980Y

- $f=0\%, T=0.1s$
- $f=0.33\%, T=0.1s$
- $f=0.33\%, T=0.5s$

Fracture in stretch flanging of high strength steel sheets

Springback angle $\Delta \theta /^{\circ}$

- Forming speed /mms


Effect of clearance ratio on occurrence of fracture for JSC980

- Limiting flanging ratio: $l_1 - l_0 / l_0$

Relationship between limiting flanging ratio and clearance ratio

Improvement of stretch flangeability by upper and lower punching

- Upper die
- Upper punch
- Lower die
- Lower punch

Relationship between limiting expansion ratio and tensile strength

Conventional ($c=20\%$)
Improvement of limiting flange height by gradually contacting punch

W/W₀=0.2, α=45°

(a) JSC980Y

W/W₀=0.2, α=45°

(b) JSC1180Y

Shrink flanging of high strength steel sheets

Gradually contacting punch for improving shrink flangeability of ultra-high strength steel sheets

Gradually contacting punch for improving shrink flangeability of ultra-high strength steel sheets

Gradually contacting punch for improving shrink flangeability of ultra-high strength steel sheets

Gradually contacting punch for improving shrink flangeability of ultra-high strength steel sheets

Before flanging

Flanging in corner

Reduction in compression stress
Gradually contacting punch for improving shrink flangeability of ultra-high strength steel sheets

After flanging

Conditions of shrink flanging

<table>
<thead>
<tr>
<th>Sheet</th>
<th>Thickness [mm]</th>
<th>Tensile strength [MPa]</th>
<th>Elongation [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>JSC590R</td>
<td>1.02</td>
<td>609</td>
<td>23</td>
</tr>
<tr>
<td>JSC980Y</td>
<td>1.02</td>
<td>1053</td>
<td>13</td>
</tr>
<tr>
<td>JSC1180Y</td>
<td>1.22</td>
<td>1215</td>
<td>8.0</td>
</tr>
</tbody>
</table>

In-situ measurement of wrinkling during shrink flanging using borescope for $\alpha=0^\circ$ and JSC1180Y
Sheets after shrink flanging for JSC980Y

Strain in x-direction

-0.12
-0.08
-0.04
0
Wrinkling

(a) $\alpha=0^\circ$
(b) $\alpha=25^\circ$

Prevention of seizure in ironing of stainless steel drawn cup by surface textured die having lubricant pockets

Electric, fuel-sell, hybrid vehicles

Stainless steel sheets
Aluminium alloy sheets

Prevention of seizure in ironing of stainless steel drawn cup by surface textured die having lubricant pockets

Die: TiCN cermet

Grinding
Polishing
Multi-stage shot peening
Polishing

Die having lubricant pockets of TiCN cermet

Remained lubricant on cup surface after ironing

Ironed cups by die having lubricant pockets and very fine surface die for SUS430 (Choleric additive lubricant)

(a) Very fine surface die by polishing, $r=17.7\%$
(b) Die having lubricant pockets, ironing ratio $r=26.7\%$

Research Topics

1) Development of forming processes of lightweight metals
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   • Prevention of wrinkling in shrinkage flanging of ultra-high strength steel sheets
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   • Prevention of seizure in deep drawing and ironing of ultra-high strength steel sheets
   • Punching process including thickening of hole edge of ultra-high strength steel sheet
   • Self-piercing riveting of high strength steel and aluminium alloy sheets
   • Mechanical clinching of high strength steel and aluminium alloy sheets
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2) Development of forming processes of lightweight parts
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3) Development of new forming processes
   • Automatic re-lubrication in forging of plates by load oscillation
   • Consolidation of iron powder by extrusion
   • In-situ measurement during stamping using borescope

Ironing
Stainless steel sheets
Battery cases
Cup
Die
Punch
Ironed cup

Seizure

Lubricant pockets

Reflection of LED
Poore
Rich

Lubricant with fluorescence

Camera
Ultraviolet rays LED

EDM
Grinding
Polishing
Multi-stage shot peening
Polishing
**Ironing limit of die having lubricant pockets**

Very fine surface die

Seizure

Fracture

No defect

Seizure

Ironing ratio r [%]

Surface roughness in land portion of die [μmRa]

0.05 0.10 0.15 0.20 0.25

0 10 20 30

No defect

**Summary: lubricant mechanism during ironing of die having lubricant pockets**

Before ironing

During ironing

(a) Very fine surface die

(b) Die having lubricant pockets

**Research Topics**

1) Development of forming processes of lightweight metals
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**Motions of mechanical servo press**

Amada SDE

Crank

Link

Soft

Pulsating 1

Programming

Pulsating 2

Pendulum

Coining

Iterative

**Reduction of friction in plate forging by load oscillation**

Plate forging

Servo press

Load oscillation

Side position

Oscillation

Time

Clank

Decrease in compressive load

Toyohashi Univ. of

**Automatic re-lubrication by load oscillation**

Plate

Lubricant

Flat die
Automatic re-lubrication by load oscillation

Loading

Flat die: elastic deformation
Concave shape

High Friction hill
Low

Plate: plastic deformation
Convex shape

Releasing
Automatic re-lubrication by load oscillation

Releasing

Load oscillation in compression using servo press

(a) No oscillation

(b) Oscillation

Variations of compressive load with stroke using servo press with and without load oscillation

Reduction in thickness: 63%

Plate forging of stainless steel SUS403 plate

(a) No oscillation

(b) Load oscillation

Load oscillation

Reduction in thickness: 63%
One day of student in laboratory

10:00  come
12:00  Lunch, break, Preparation
15:00  Break
18:00  Dinner, Return

Class
Newspaper
Experiment
Meeting, data treatment
E-mail

Student rooms

30 students
3 room

Room 1
Room 2
Room 3
Thank you very much