

# Lecture 4 & 5

# Materials and Manufacturing

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# Goal of Lecture 3 & 4

- Once you finish your conceptual design, you will start generating engineering drawings.
- Now it is time to think about

*What materials will you use ?*

*Which material characteristic is the most important ?*

*How much is the material cost ?*

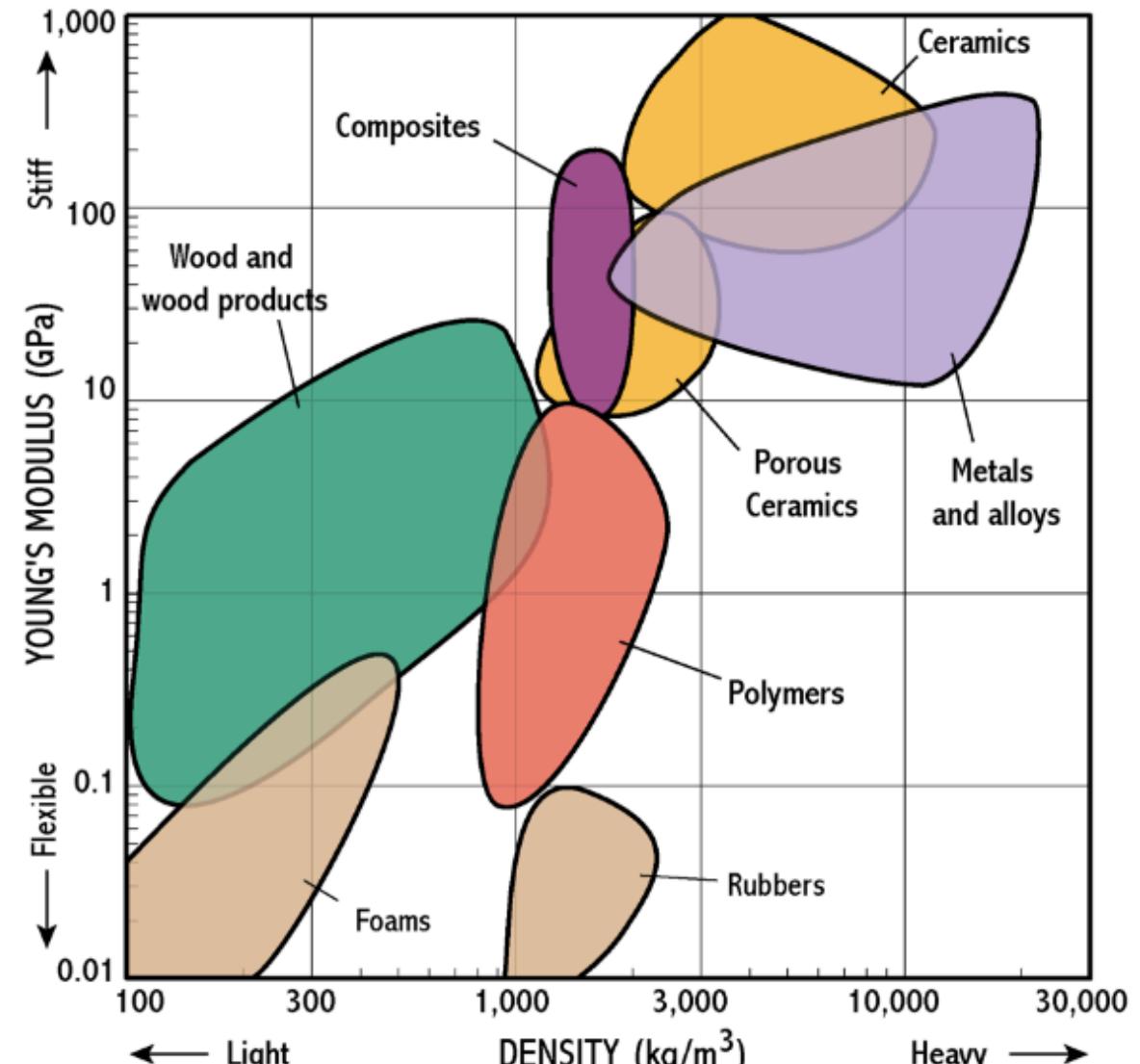
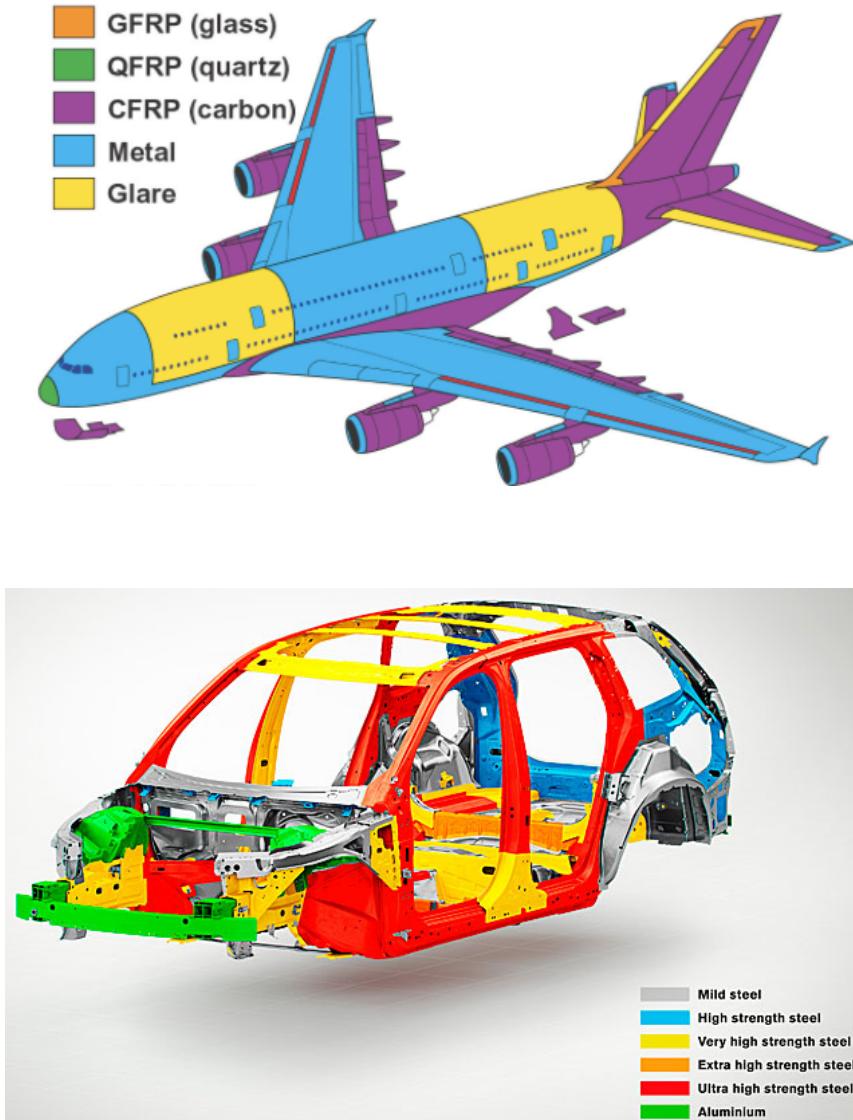
*Is your design easy to manufacture ?*

*How much does it cost to manufacture it ?*

*How long does it take to produce it ?*

*How easy is the assembly process ?*

# Selection of engineering materials



< Ashby's material map >

# Why we learn manufacturing ?

- ***A good engineering designer should be able to***

*generate an optimal design*

***Functional thinking  
Scientific knowledge***

*of an innovative product*

***Creativity***

*that can be efficiently  
manufactured*

***Design for Manufacture  
Design for Assembly***

*using proper engineering  
materials*

***Understanding of  
material characteristics***

# Lecture 4. Metallic materials and manufacturing processes

*Dr. ByungChul (Eric) Kim*

# Basic approaches to part manufacture

## 1 **Machining**

Take a block of material and cut away what you don't want

## 2 **Casting**

Fill a tool cavity with a material in liquid form and convert it to a solid

## 3 **Forming**

Take a piece of material and force it to the shape that you want

## 4 **Joining**

Assemble the part from smaller formed parts, e.g. by spot welding or with rivets

## 5 **Additive**

Build the part up layer by layer

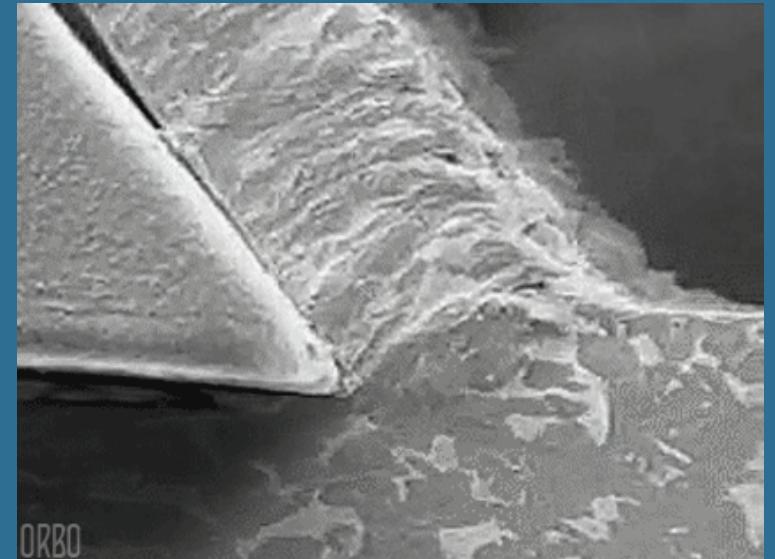
## **Machining**

- **Casting**
- **Forming**
- **Joining**
- **Additive**

*Milling  
Turning  
Drilling  
Boring  
Hobbing  
Broaching*

*Grinding  
Water jet cutting*

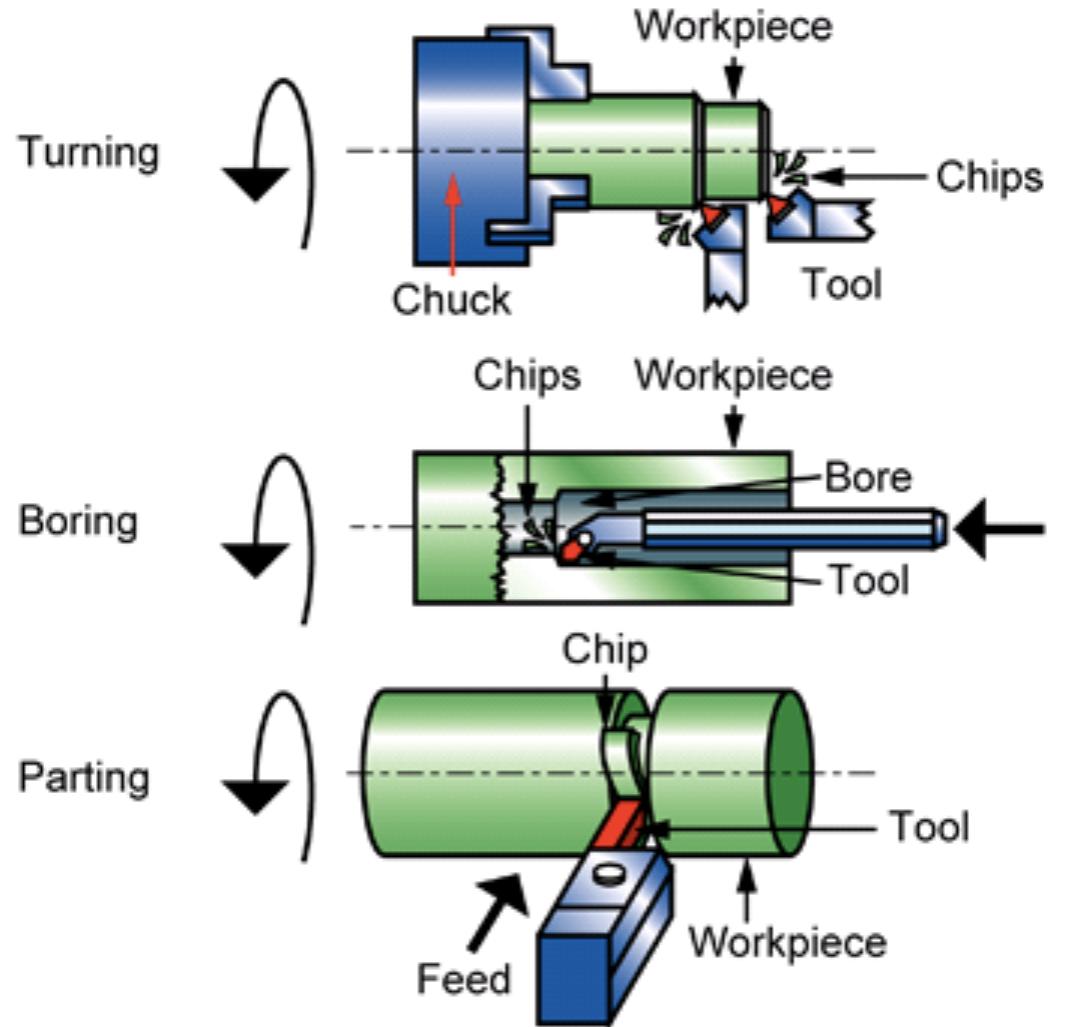
*Electro-Discharge Machining  
Thermal cutting*



ORBO

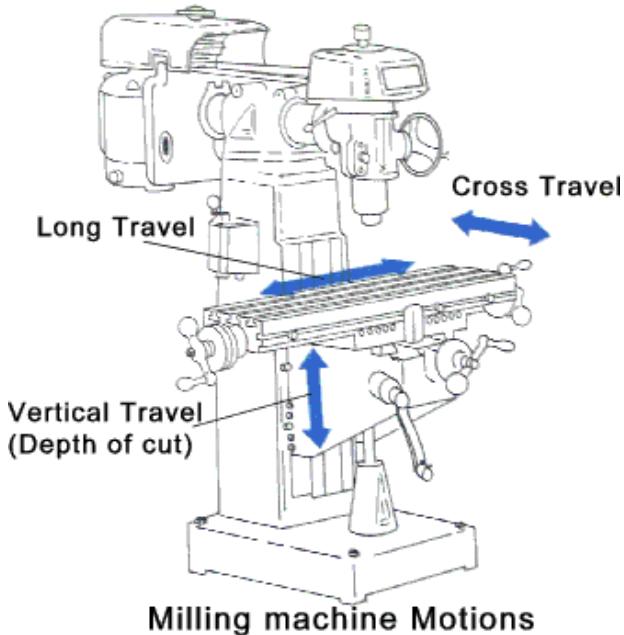
# Machining > Cutting

- **Turning (Lathe cutting)**

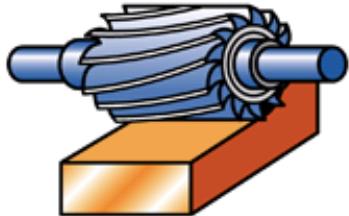


# Machining > Cutting

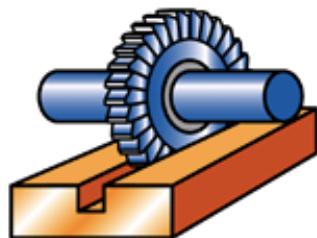
- ***Milling***



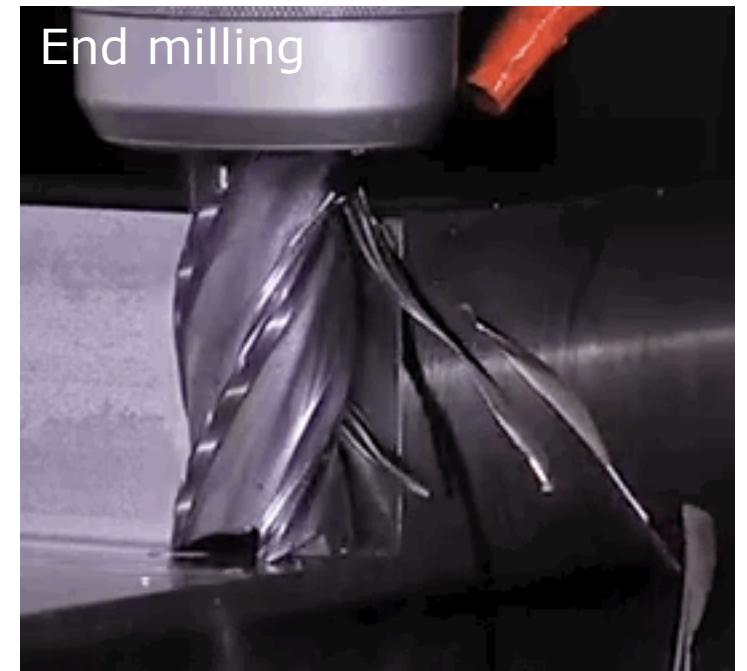
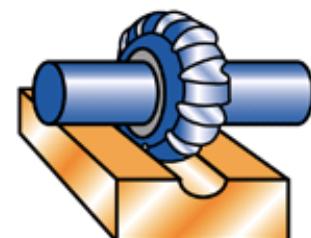
Slab milling



Slotting

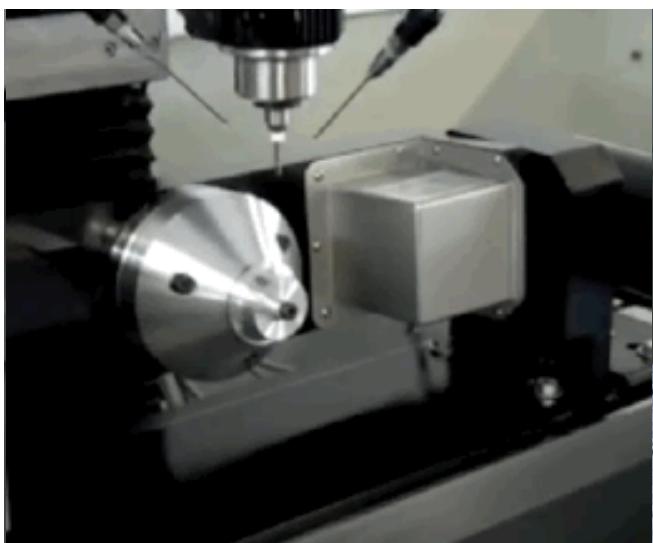
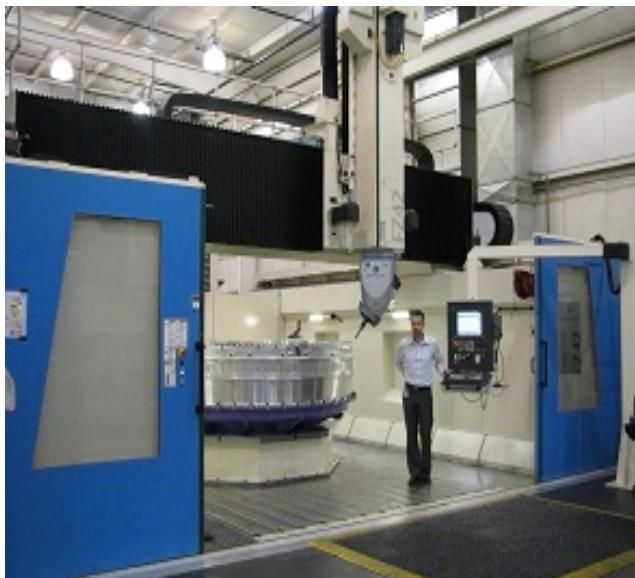


Form milling



# Machining > Cutting

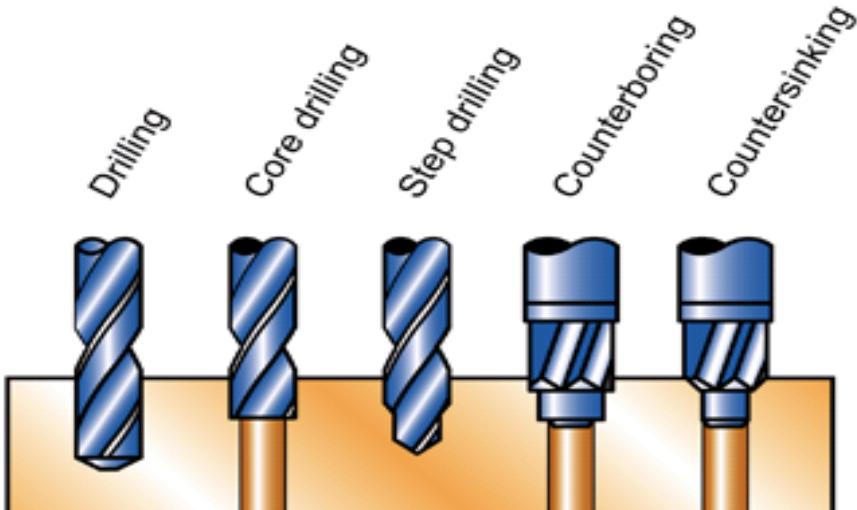
- Multi-axis CNC (Computer Numerical Control) machine



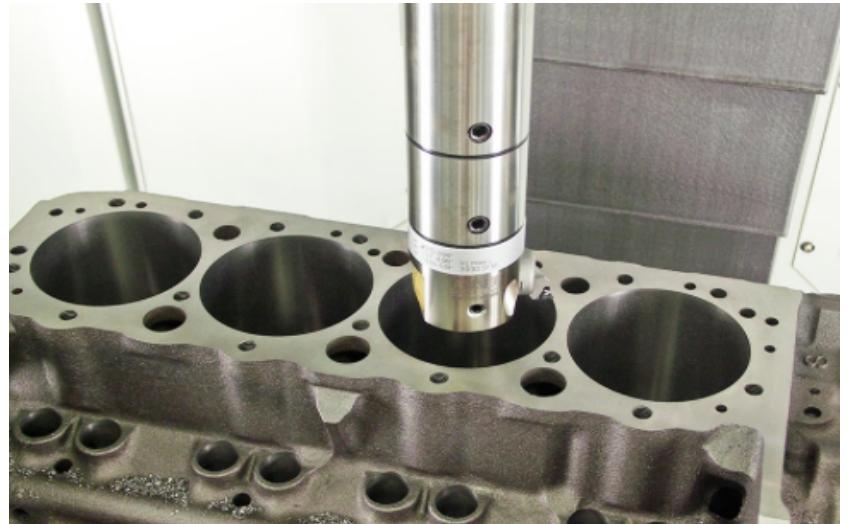
- ✓ Complex machining
- ✓ High cutting speed
- ✓ Excellent surface finishing
- ✓ Expensive machine & machining cost
- ✓ Special training required

# Machining > Cutting

- ***Drilling***



- ***Boring***



- ***Reaming***



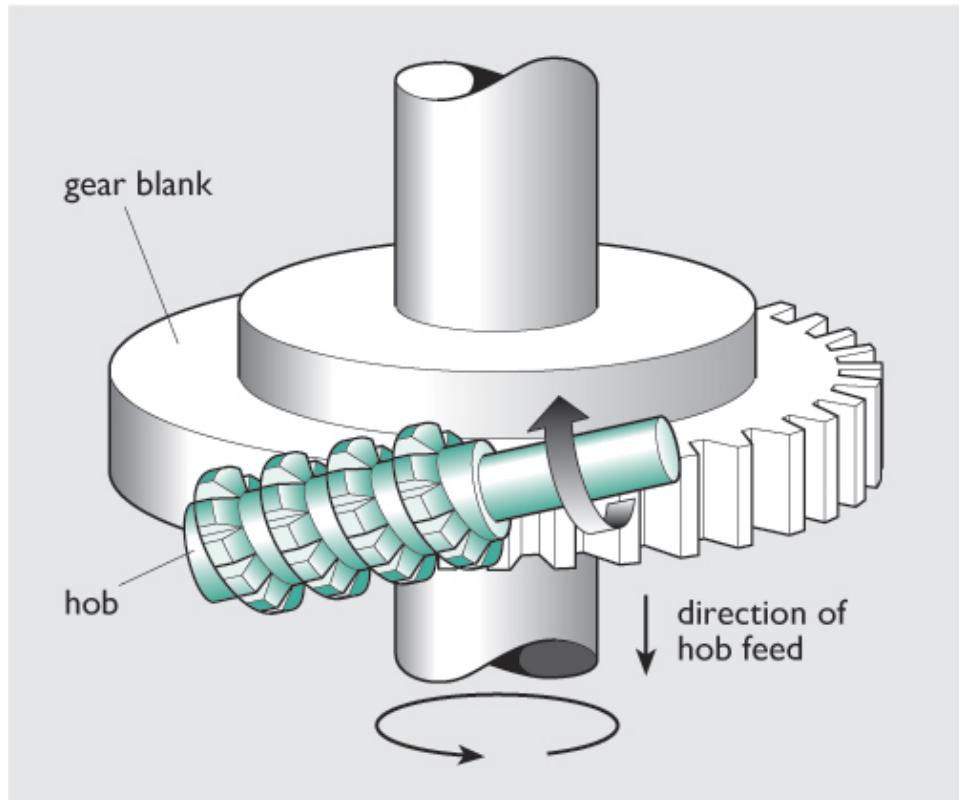
- ***Honing***



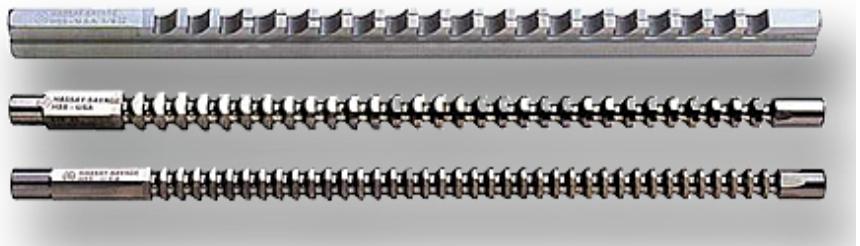
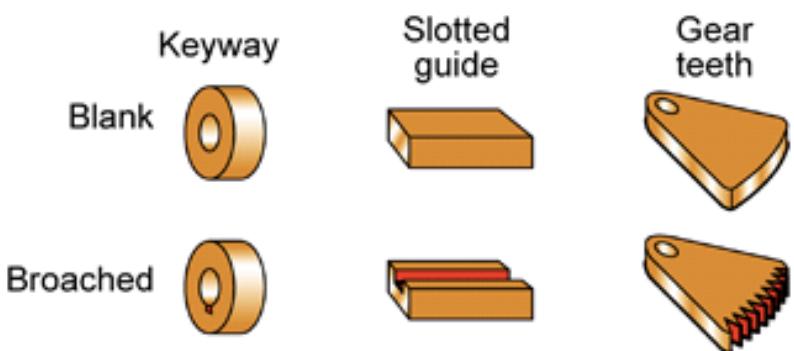
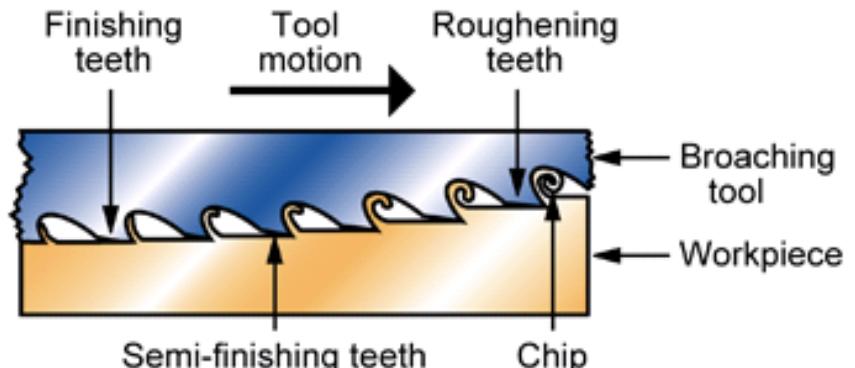
Abrasive  
machining,  
Not cutting

# Machining > Cutting

- **Hobbing**

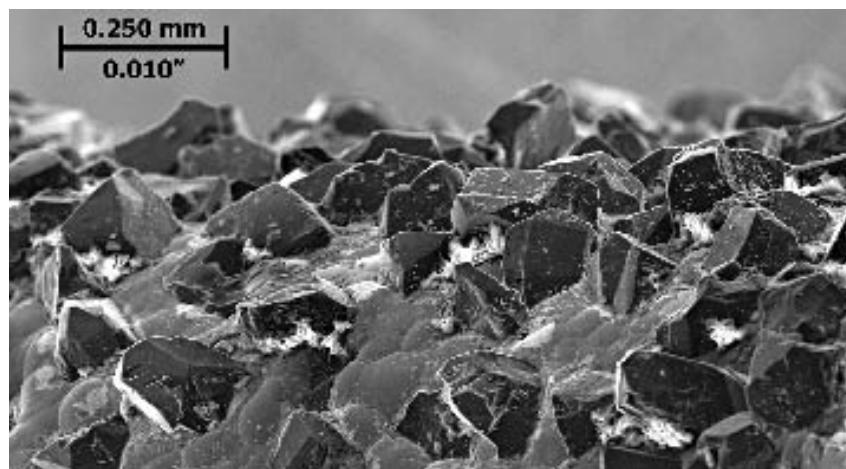
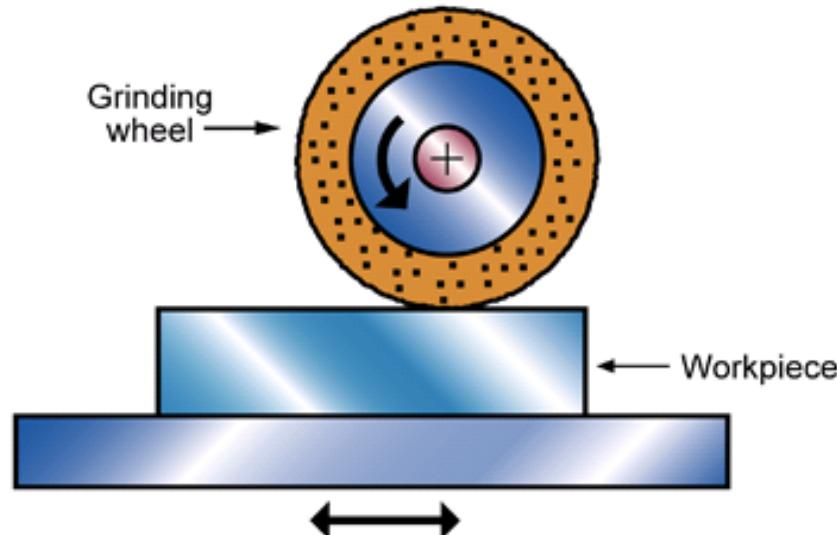


- **Broaching**

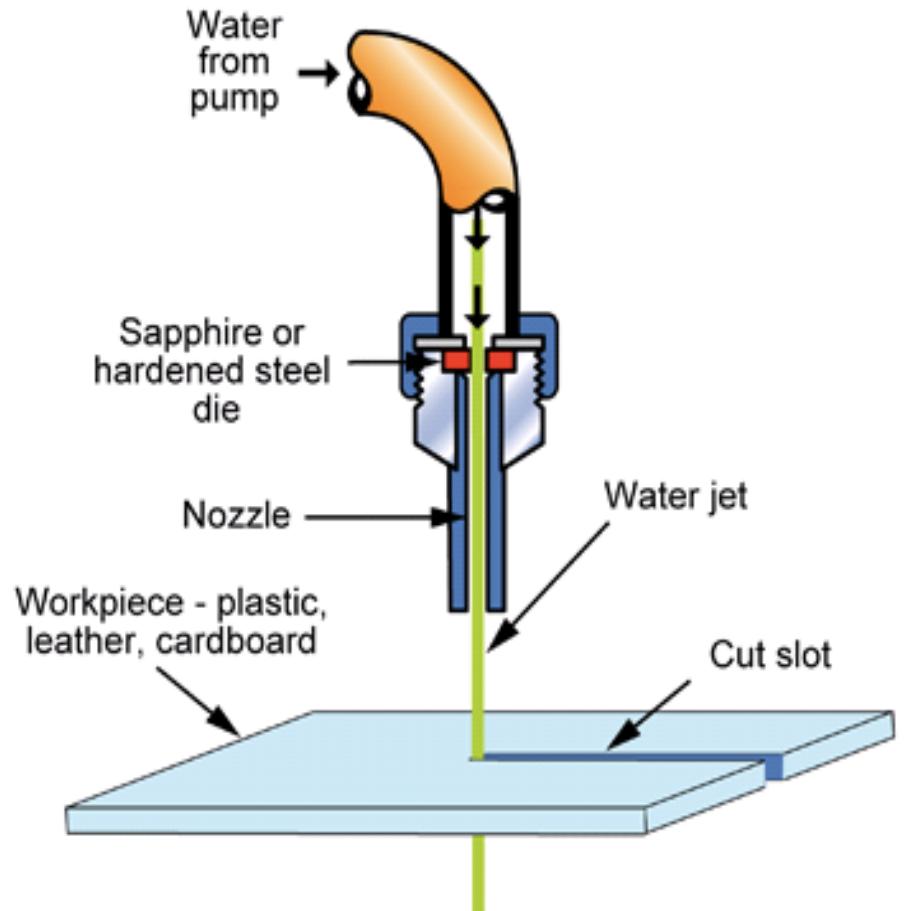


# Machining > Abrasive

- ***Grinding***



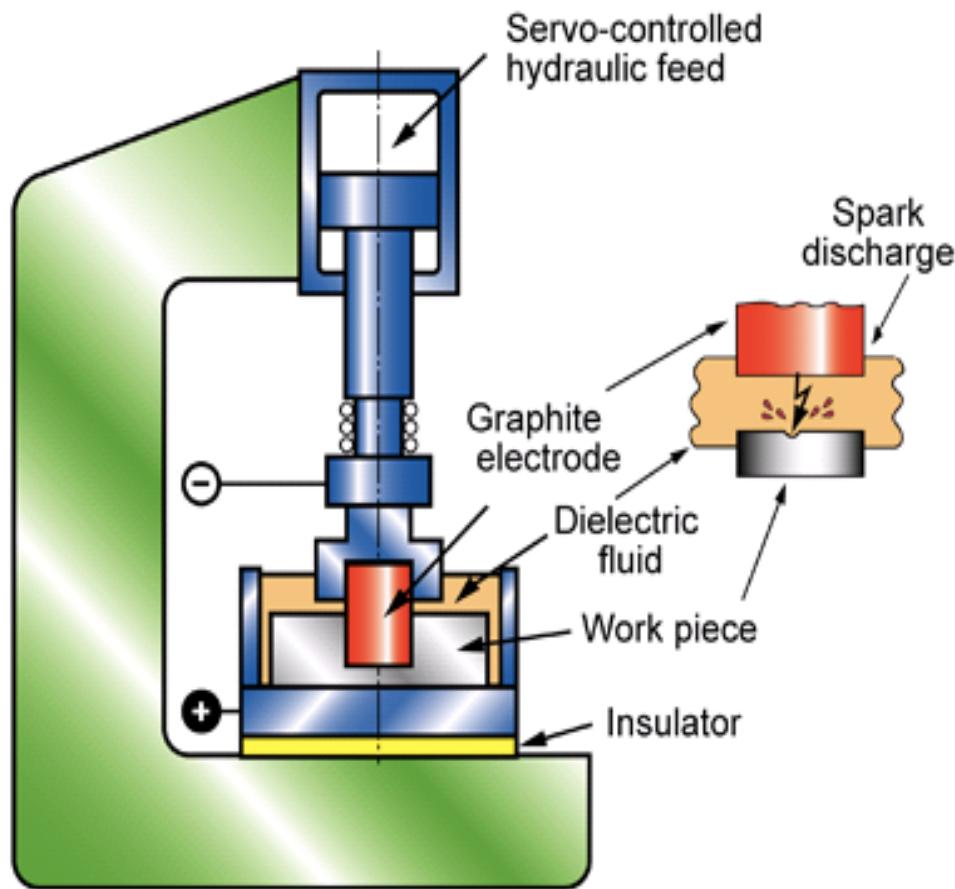
- ***Water jet cutting***



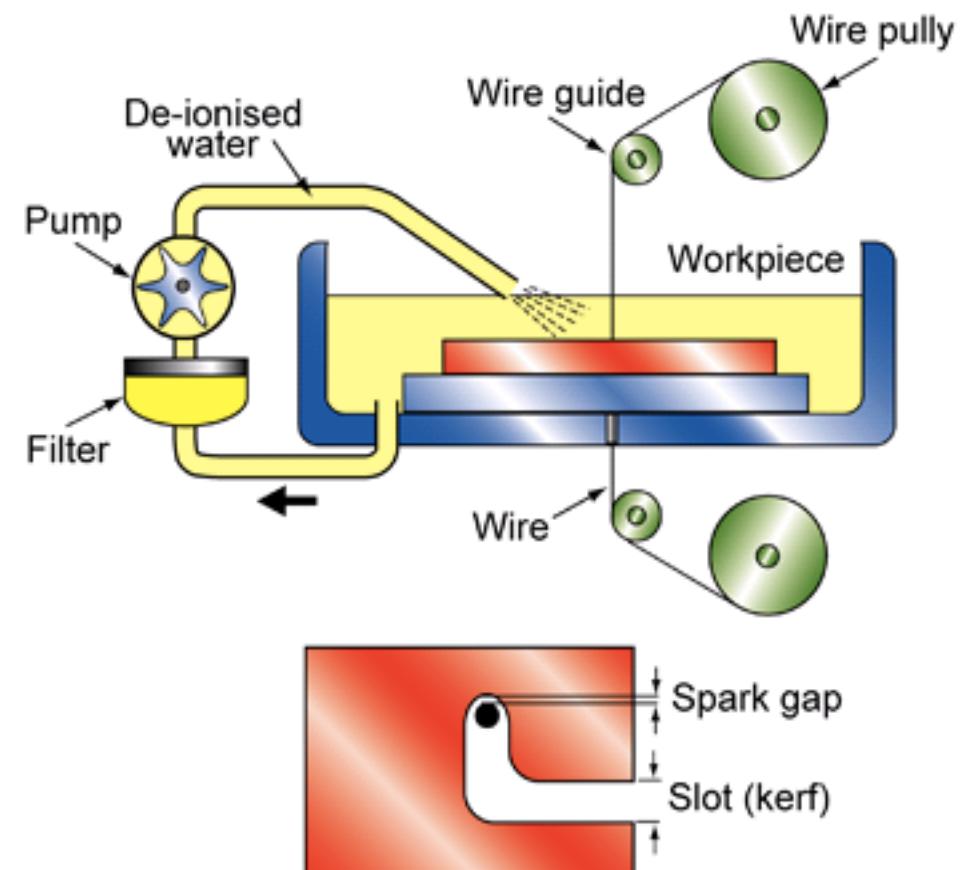
# Machining > Electrical & Chemical

- **EDM (Electro-Discharge Machining)**

Die-sink EDM

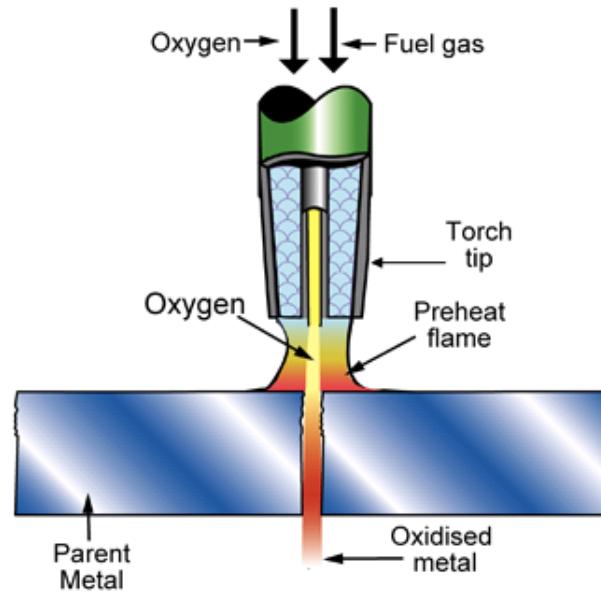


Wire-cut EDM

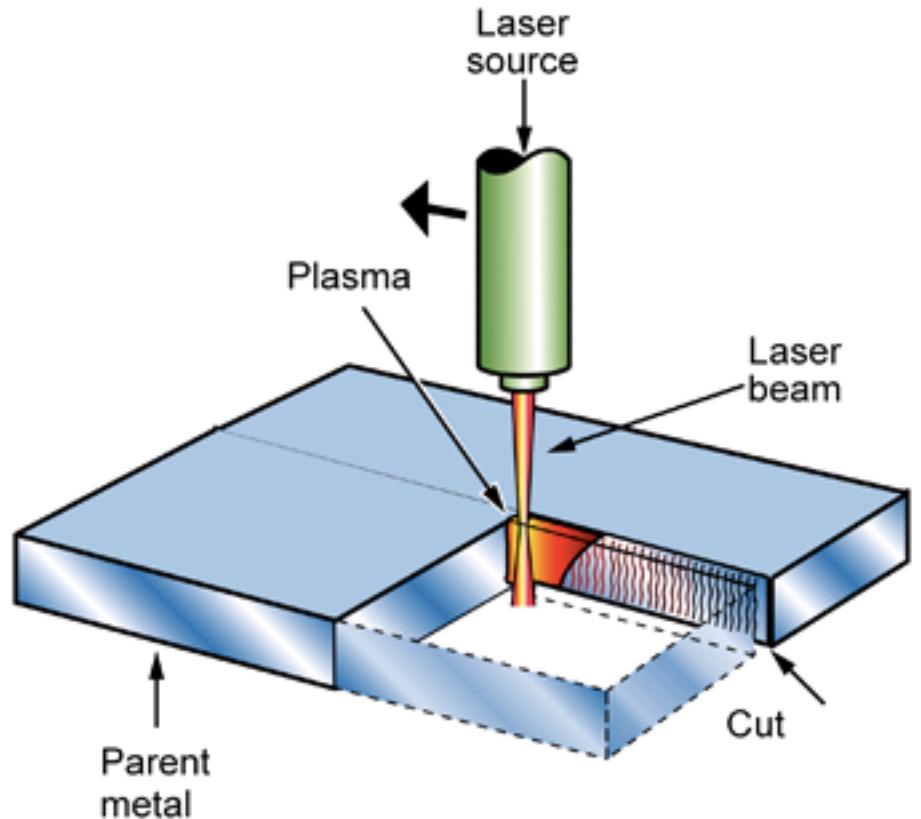


# Machining > Thermal

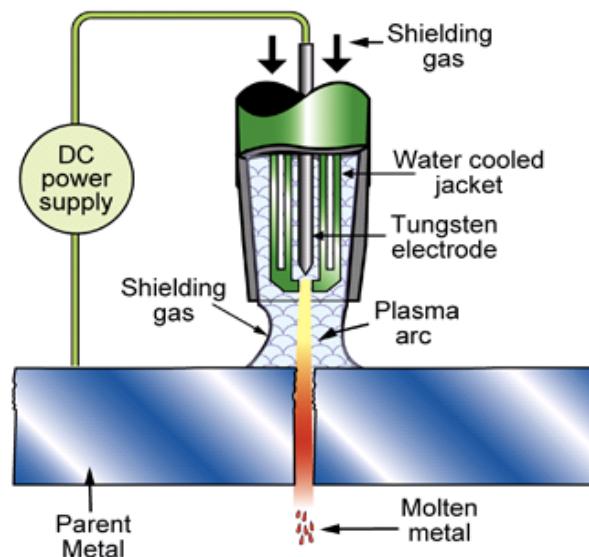
- **Oxyfuel gas cutting**



- **Laser cutting**



- **Plasma arc cutting**



- **Machining**
- **Casting**
- **Forming**
- **Joining**
- **Additive**

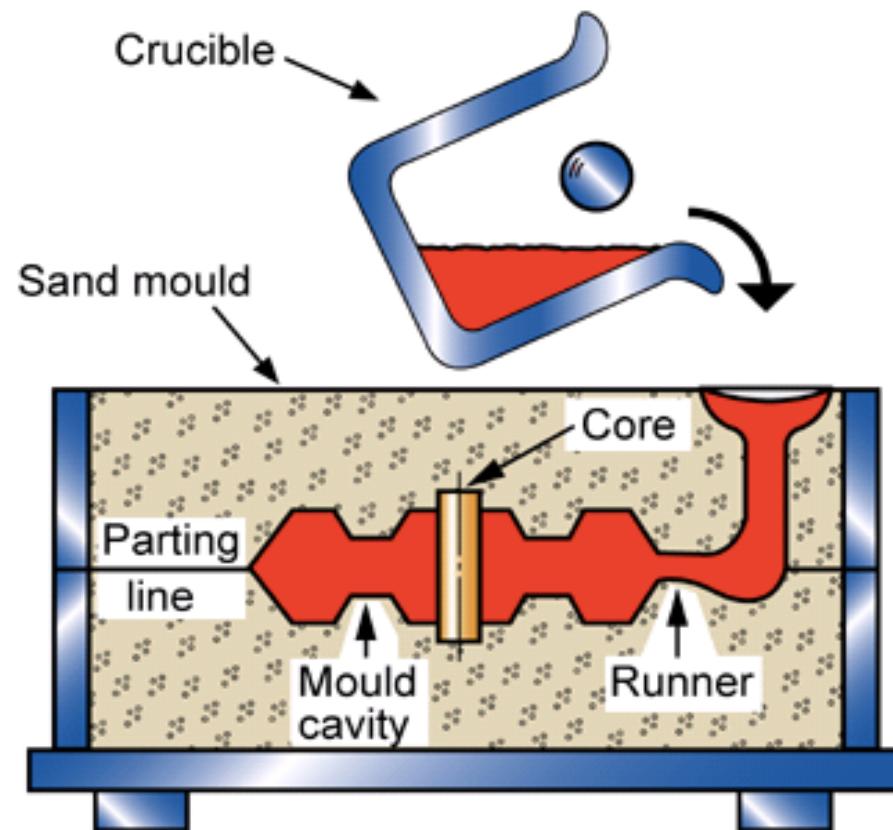
*Sand casting  
Investment casting*

*High pressure die casting  
Squeeze casting*

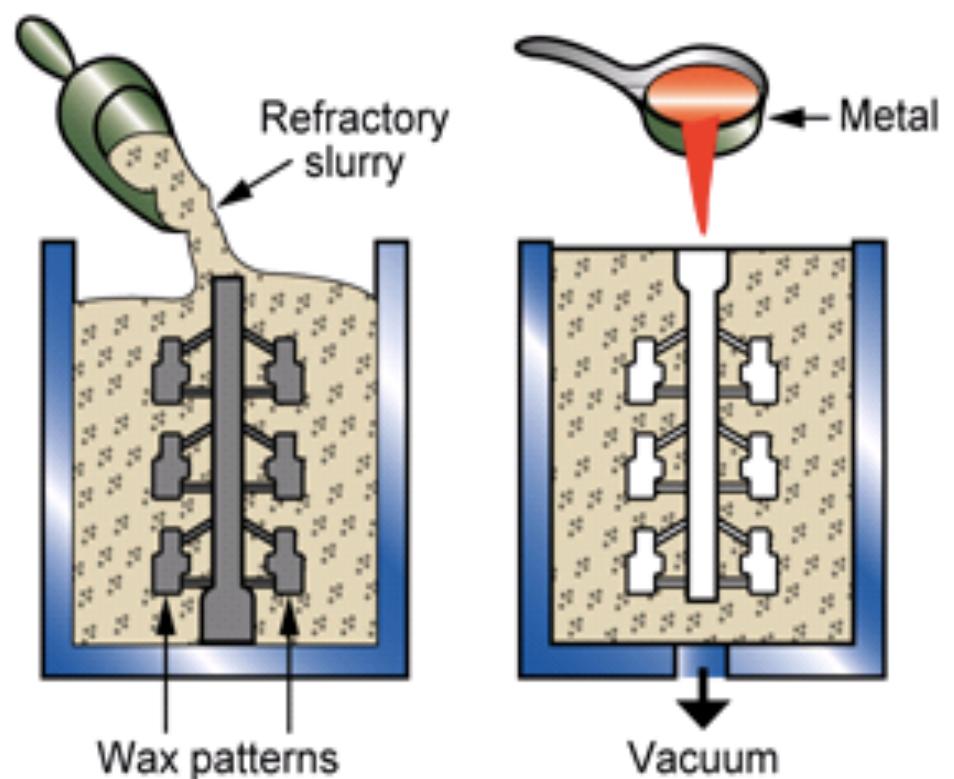
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# Casting

- ***Sand casting***

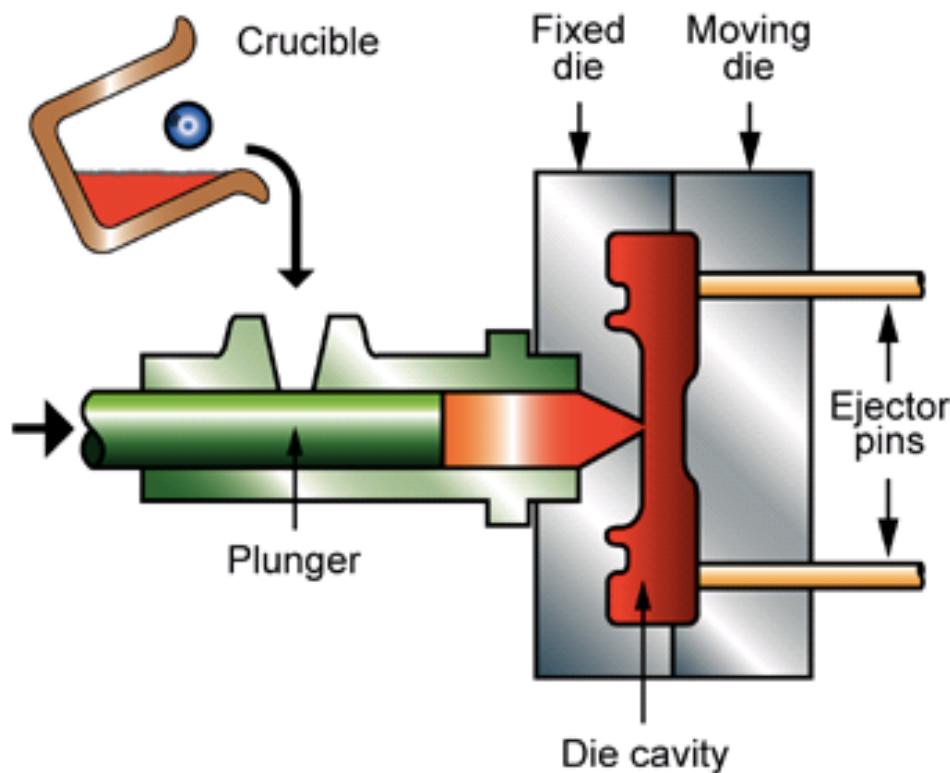


- ***Investment casting (lost wax)***

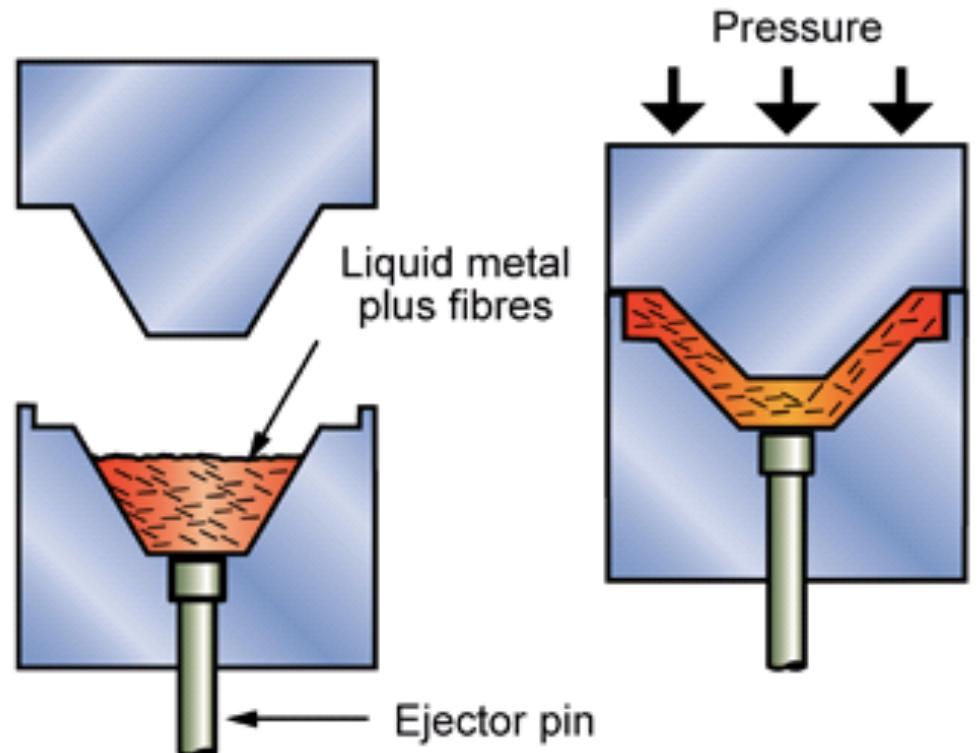


# Casting

- ***High pressure die casting***



- ***Squeeze casting***



- **Machining**

- **Casting**

- **Forming**

- **Joining**

- **Additive**

*Sheet forming*

- *Press forming*
- *Roll forming*
- *Superplastic forming*
- *Hydroforming*

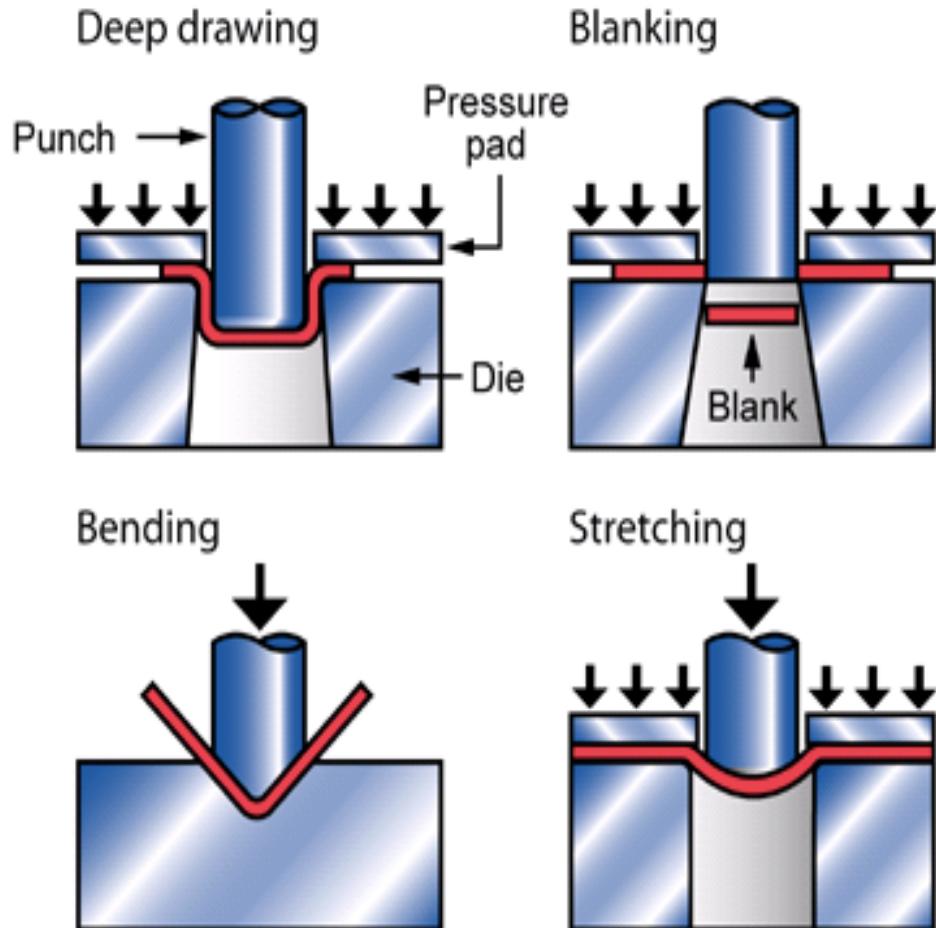
*Bulk forming*

- *Extrusion*
- *Forging*

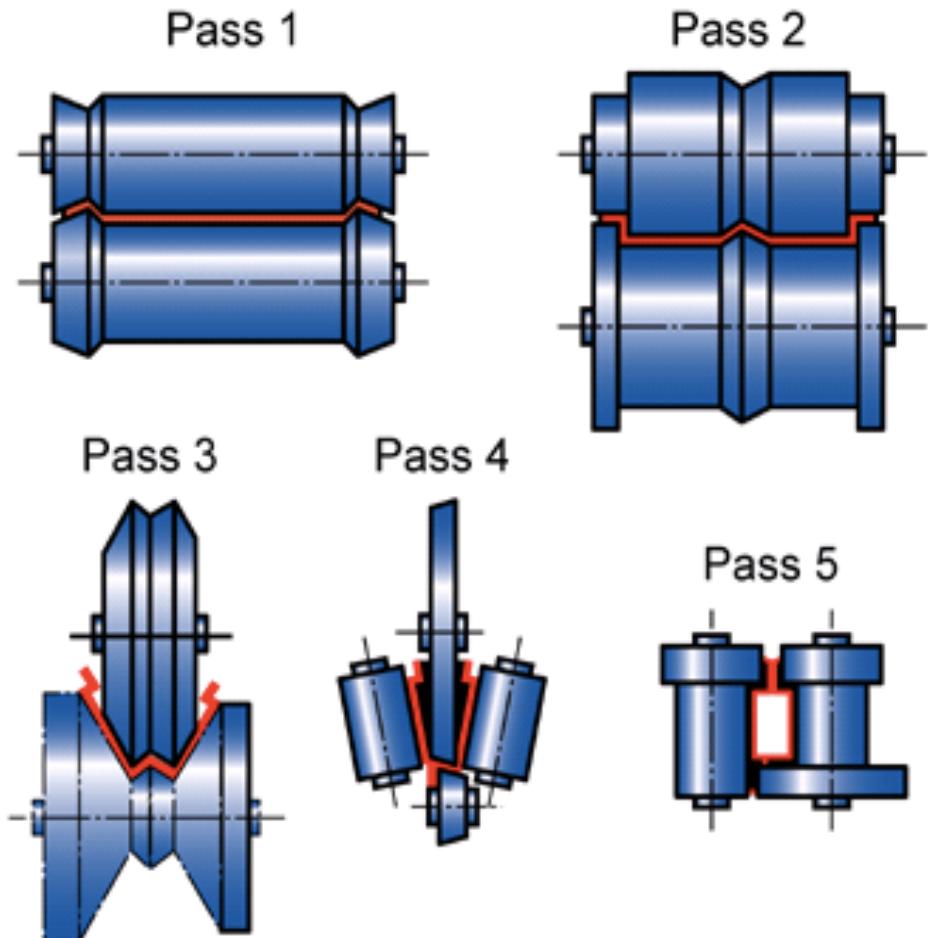
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# Forming > Sheet-forming

- ***Press forming***

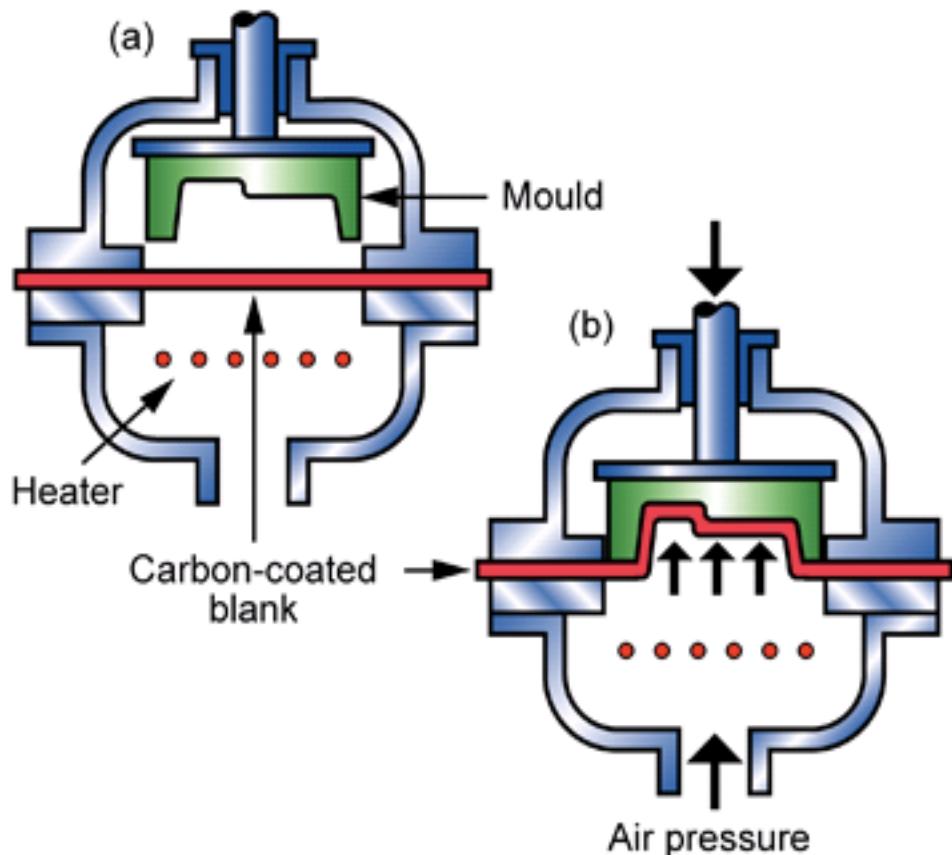


- ***Roll forming***

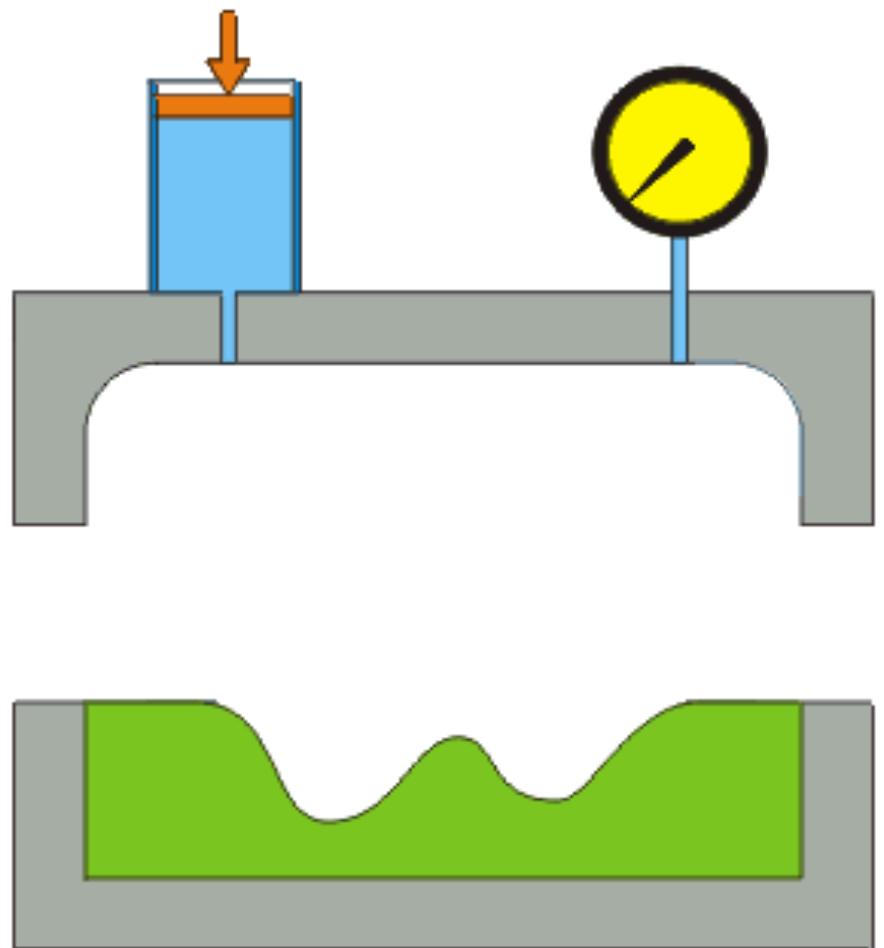


# Forming > Sheet-forming

- ***Superplastic forming***

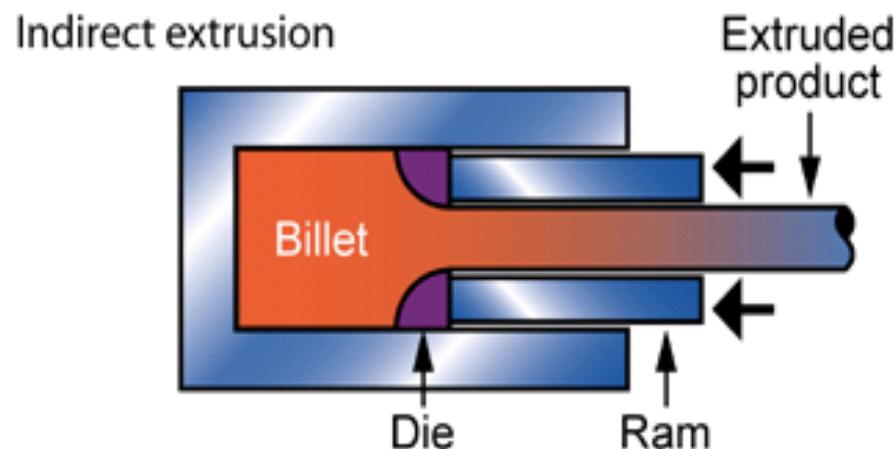
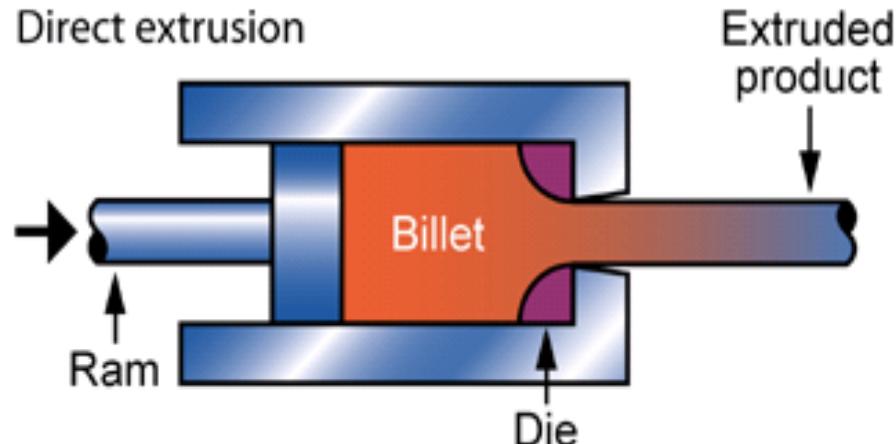


- ***Hydroforming***

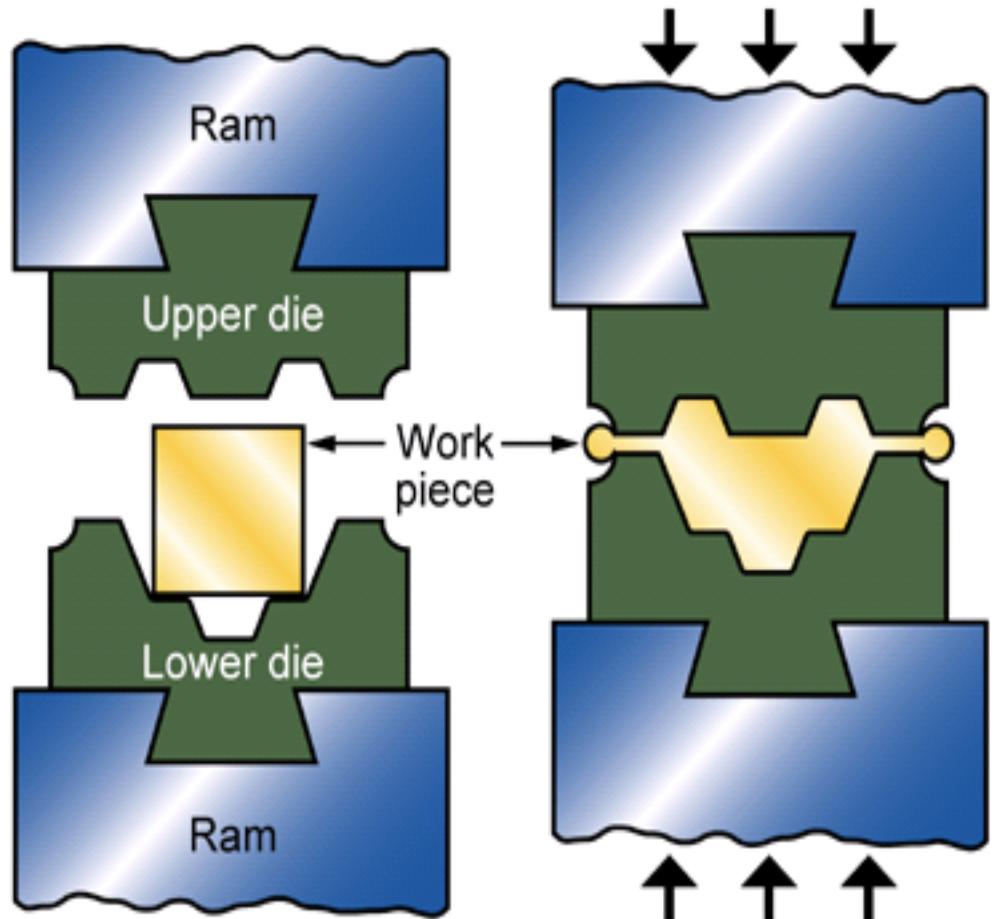


# Forming > Bulk forming

- ***Extrusion***



- ***Forging***



- **Machining**
- **Casting**
- **Forming**
- **Joining**
- **Additive**

*Adhesive bonding*

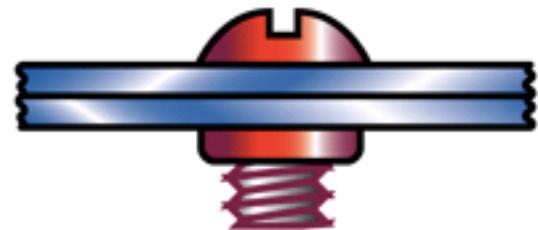
*Bolting*  
*Riveting*

*Welding*

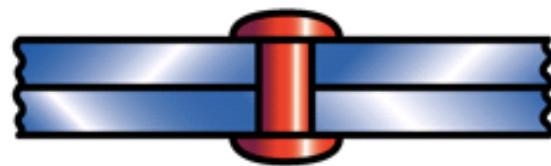
- *Arc welding*
- *Spot welding*
- *Laser welding*
- *Friction welding*

# Joining

- **Bolting**



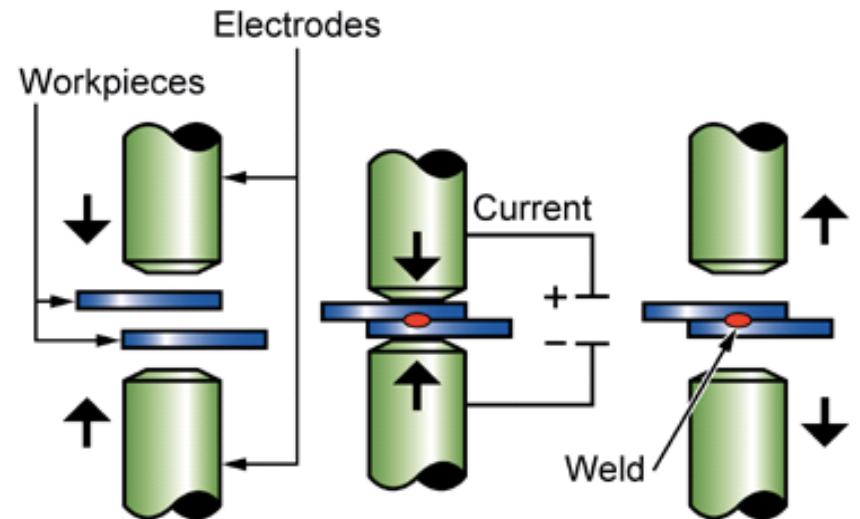
- **Riveting**



- **Adhesive bonding**

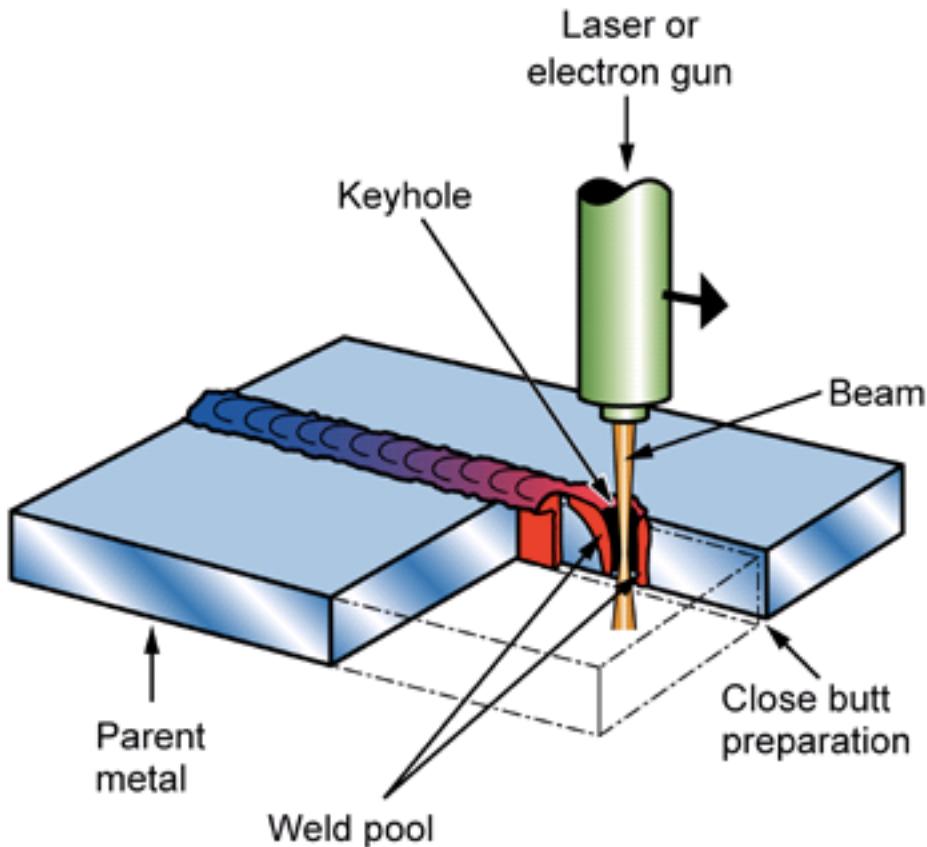


- **Spot welding**

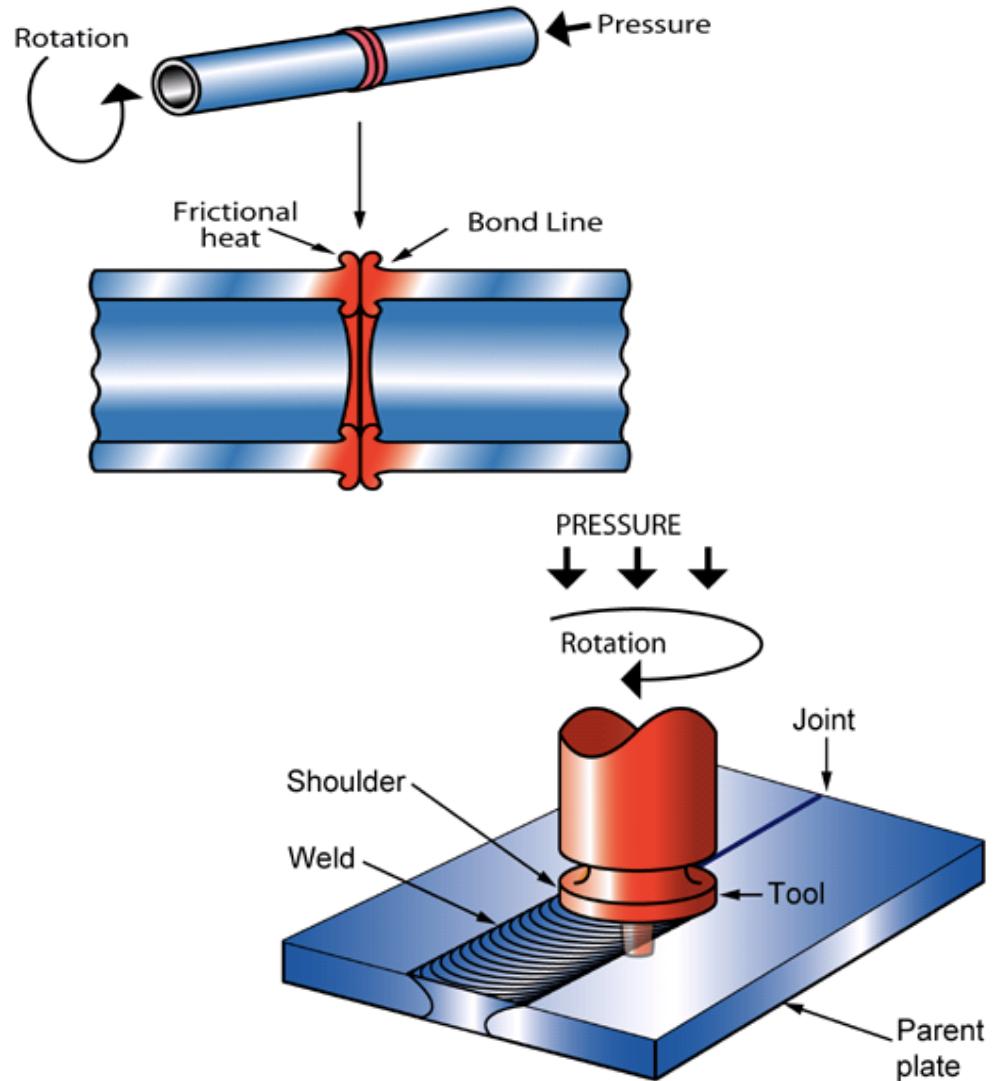


# Joining > Welding

- **Laser welding**



- **Friction welding**



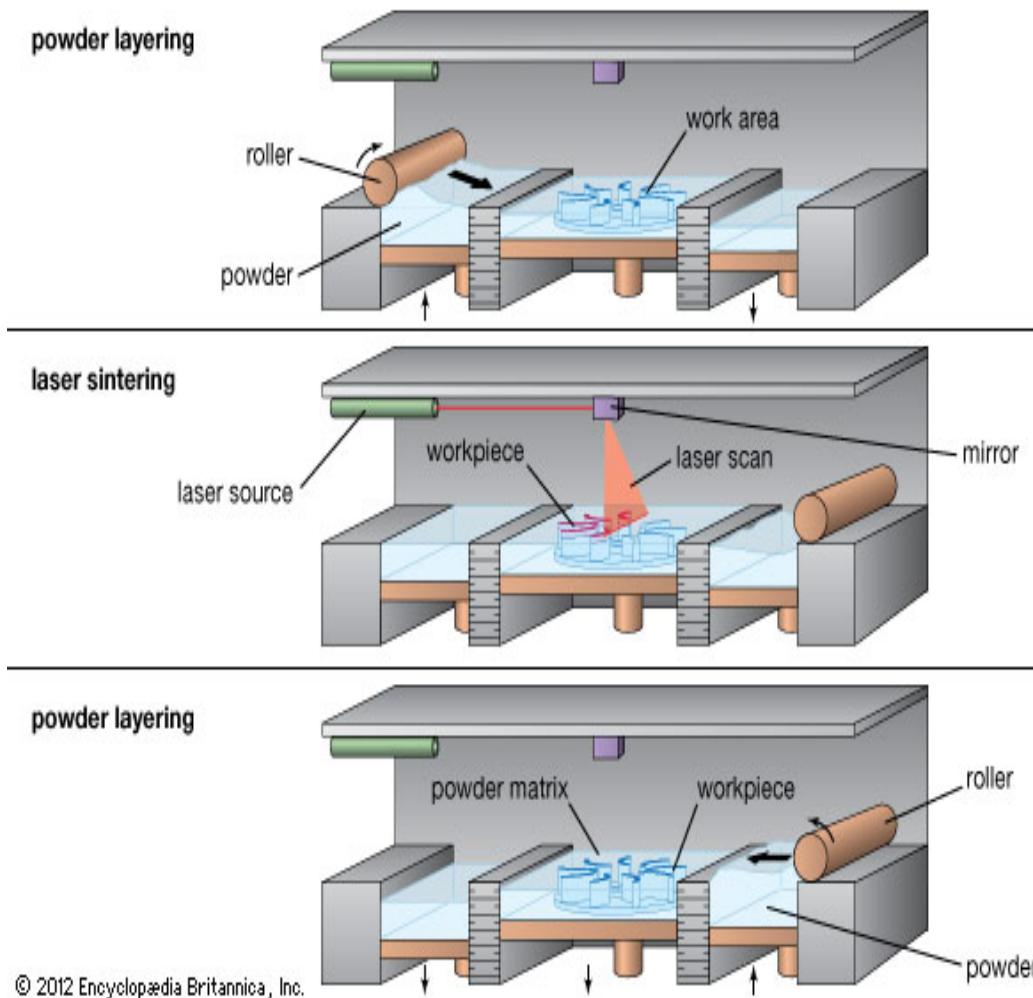
- **Machining**
- **Casting**
- **Forming**
- **Joining**
- **Additive**

*DMLS (Direct Metal Laser Sintering)  
LMD (Laser Metal Deposition)*

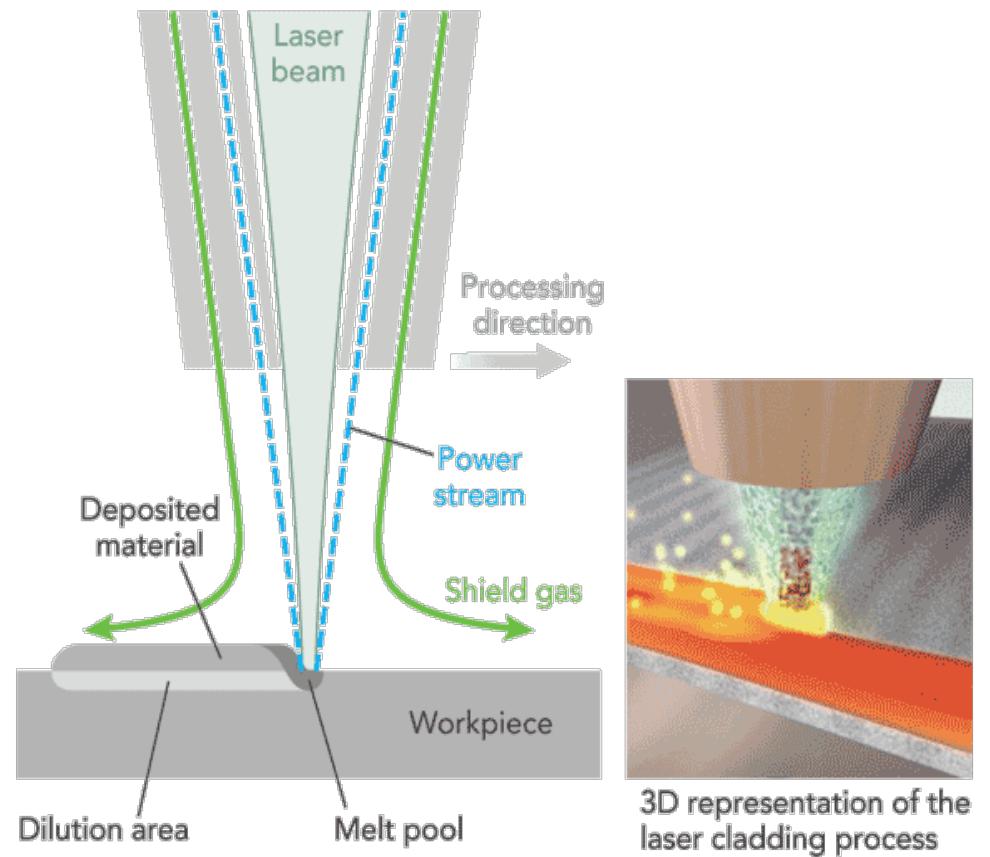
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# Additive manufacturing for metals

- **DMLS (Direct Metal Laser Sintering)**

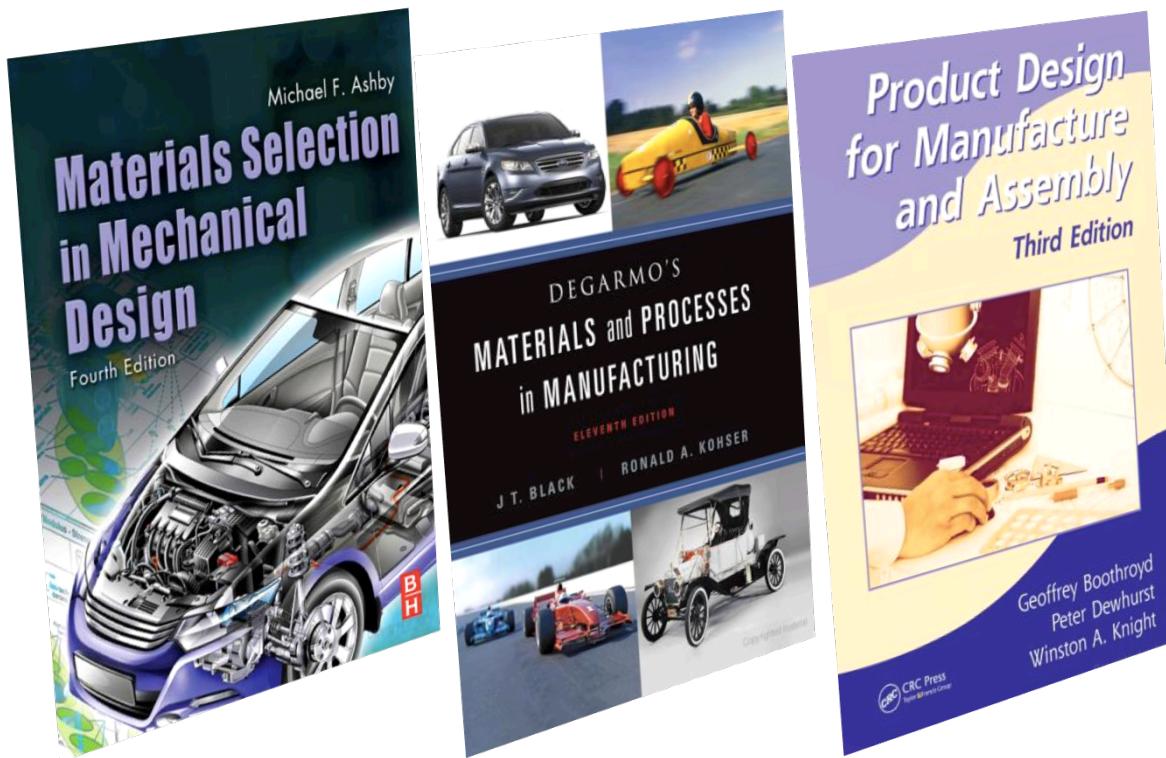


- **LMD (Laser Metal Deposition)**



<http://www.industrial-lasers.com/articles/print/volume-250/issue-6/features/laser-metal-deposition.html>

# References



Michael F. Ashby. Materials Selection in Mechanical Design 4th ed., Butterworth-Heinemann, 2011.

E. Paul Degarmo, J T. Black, Ronald A. Kohser. Degarmo's Materials and Processes in Manufacturing 11th ed., John Wiley & Sons, 2011.

Geoffrey Boothroyd, Peter Dewhurst, Winston A. Knight. Product Design for Manufacture and Assembly 3rd ed., CRC Press, 2010.

CES EduPack 2014 is available in computer rooms for students.



# Next Lecture

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## Lecture 5. Non-metallic materials and manufacturing processes