Anyagtudomány és Technológia Tanszék

Welding

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Materials Engineering
BMEGEMTBGF1
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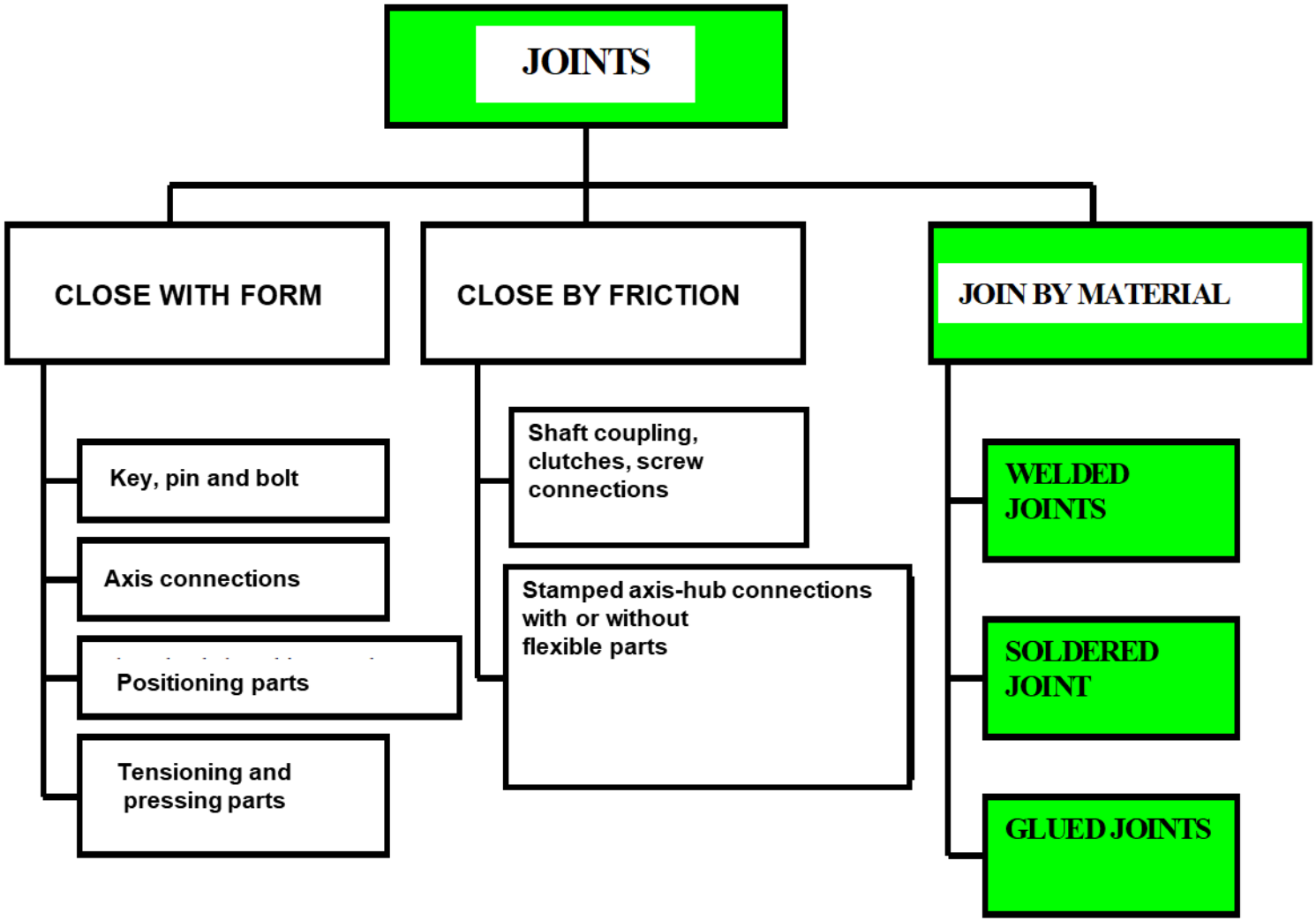
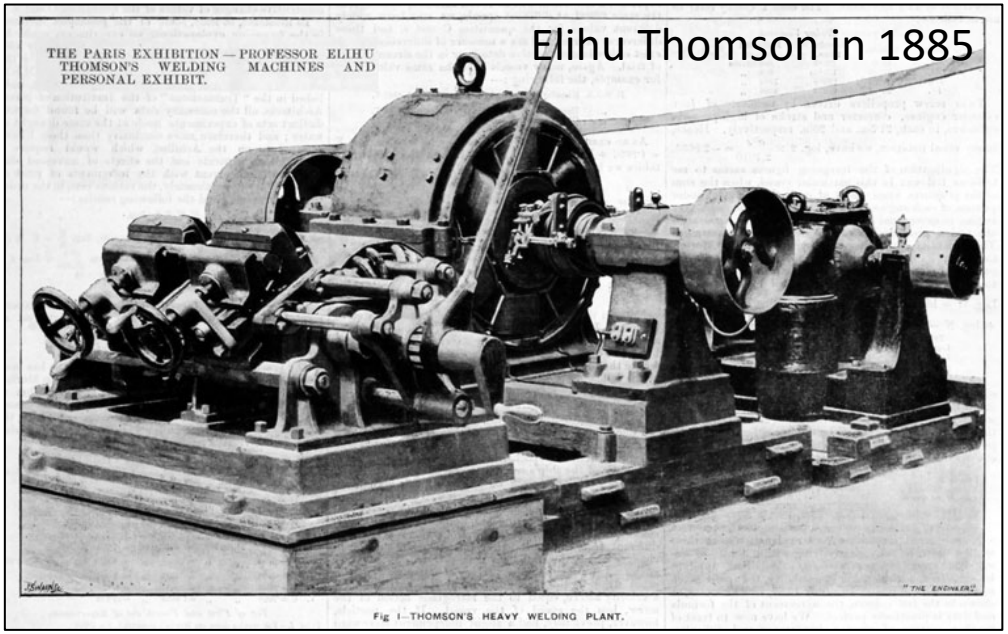
Classifying joining processes



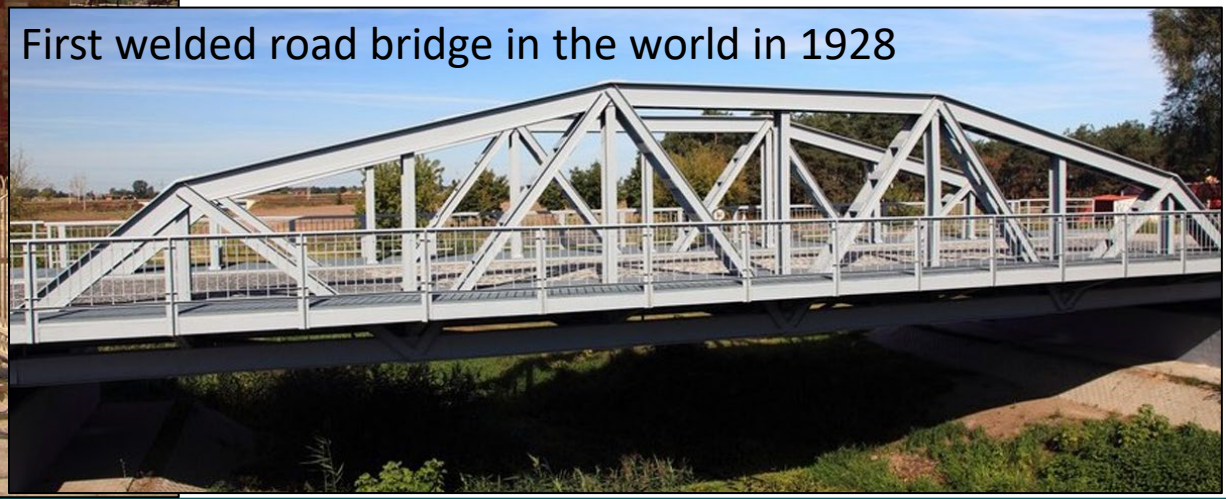
Historical overview

Iron pillar of Delhi, erected in Delhi, India about 310 AD

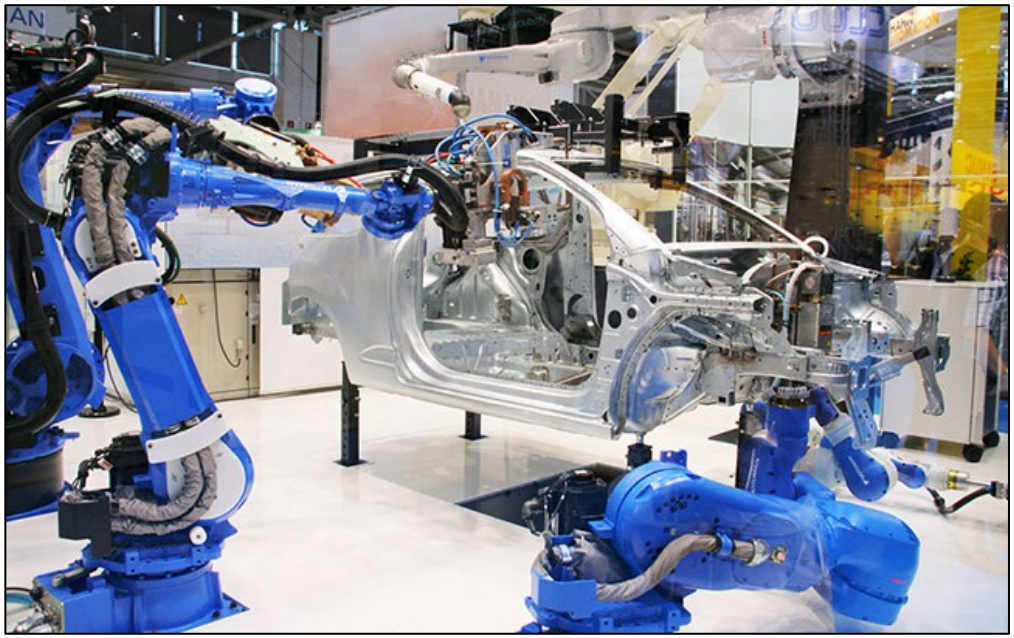
Elihu Thomson in 1885

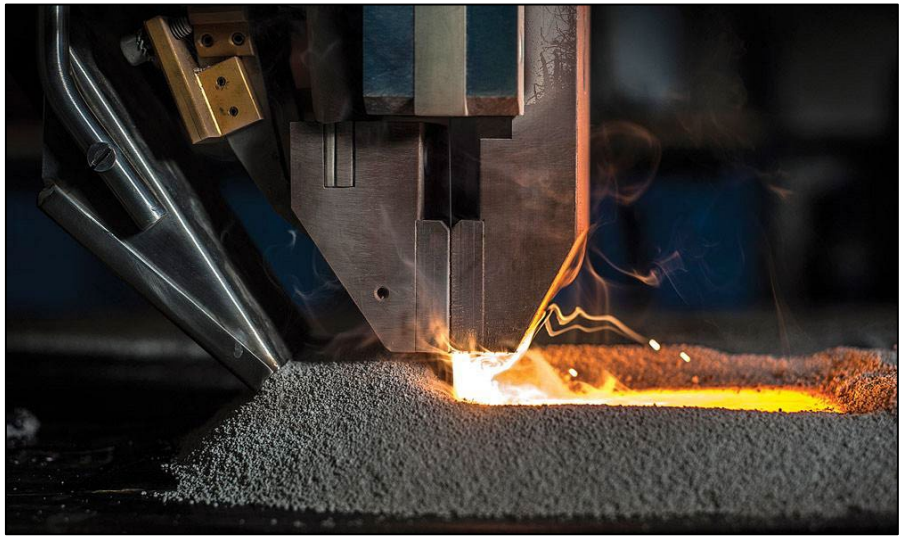


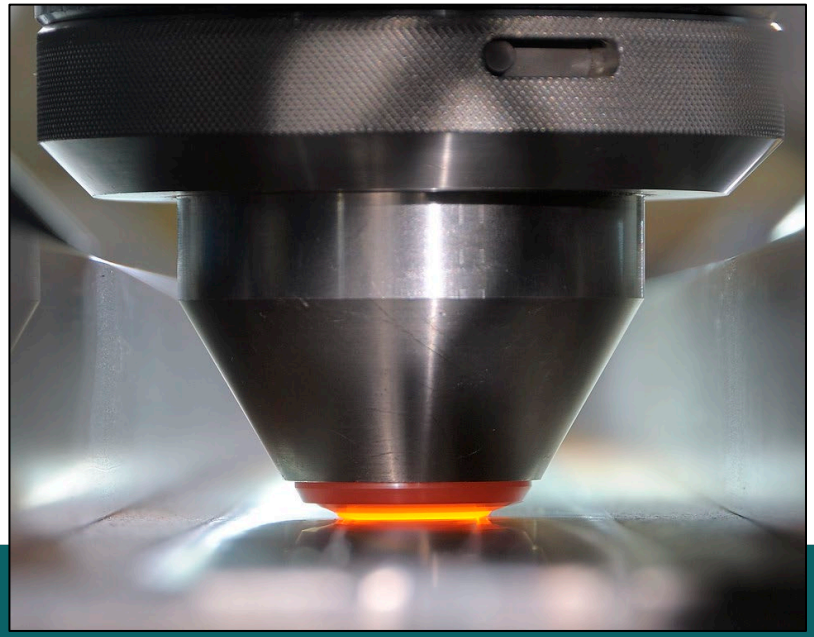
First welded road bridge in the world in 1928



Welding nowadays





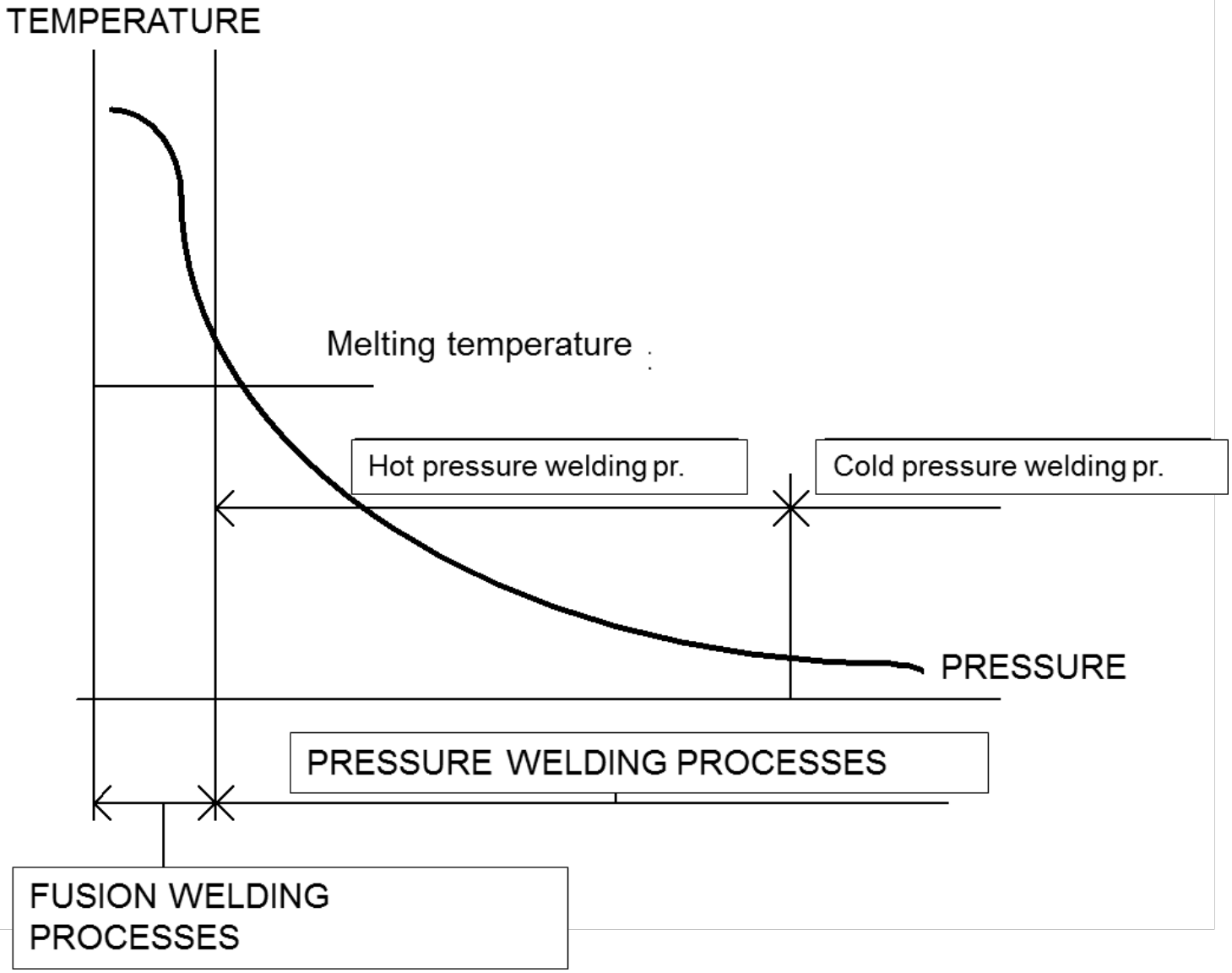


Classifying the welding processes

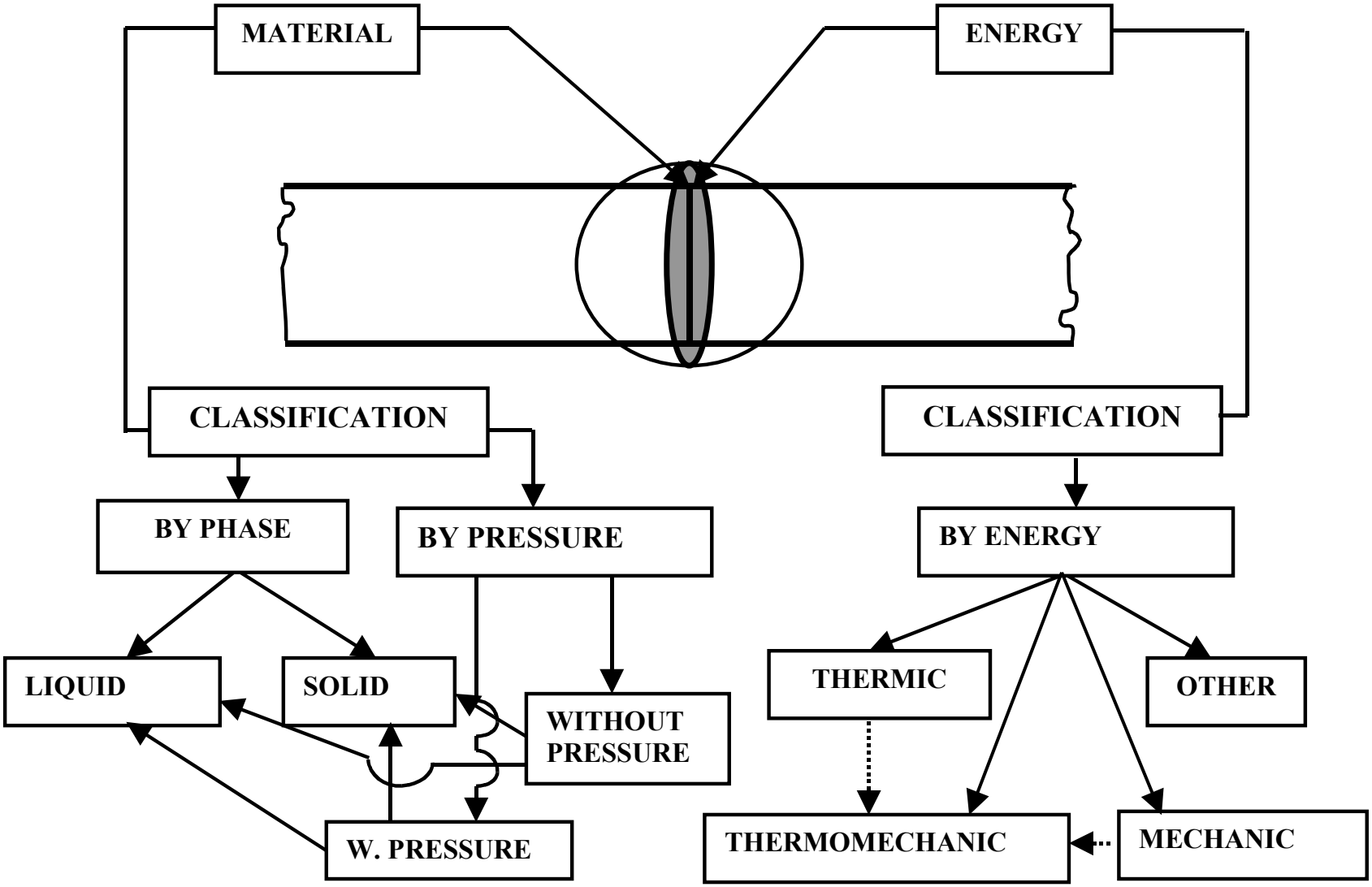
- Based on the source of energy used to create joint
- Based on the filler material type
- Based on the protection of the weld
- Based on the level of mechanizing or automation
- Based on the technological parameters.

Most frequently the source of energy is the classifying criterion.

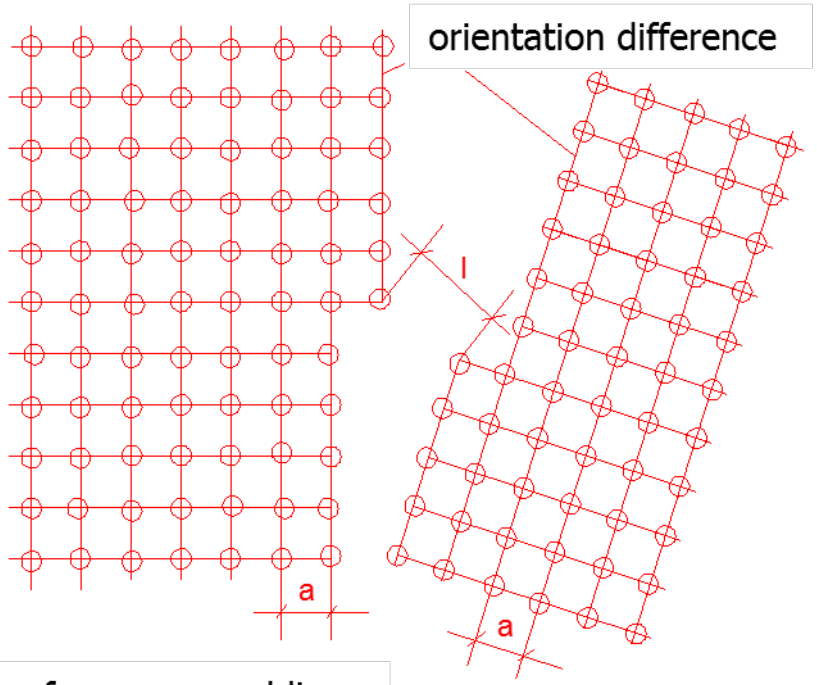
Another possible arrangement



Creating a weld bead

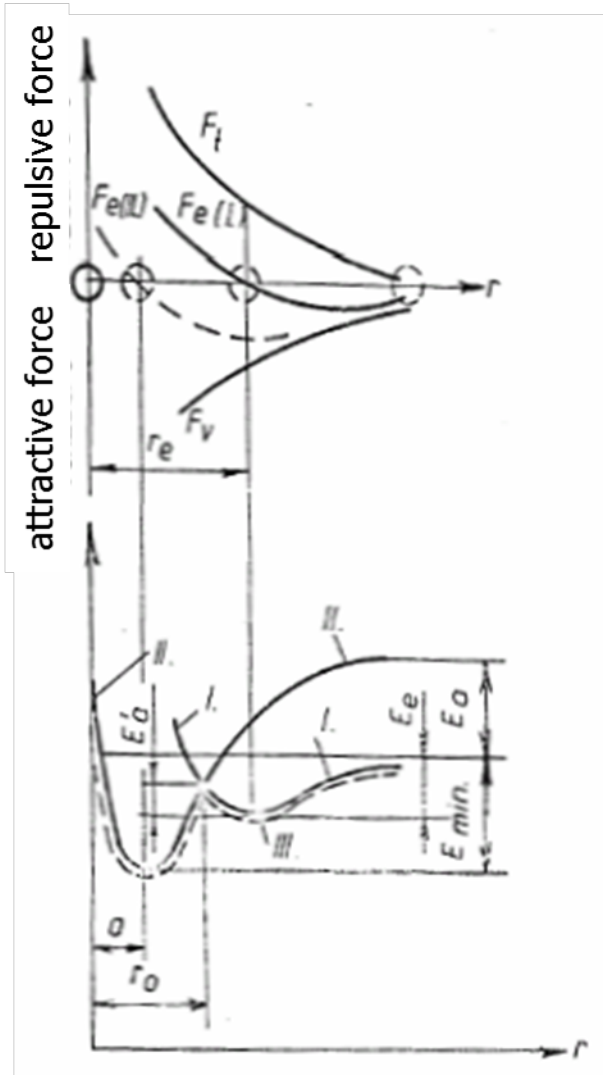


Creating the weld bead – pressure processes

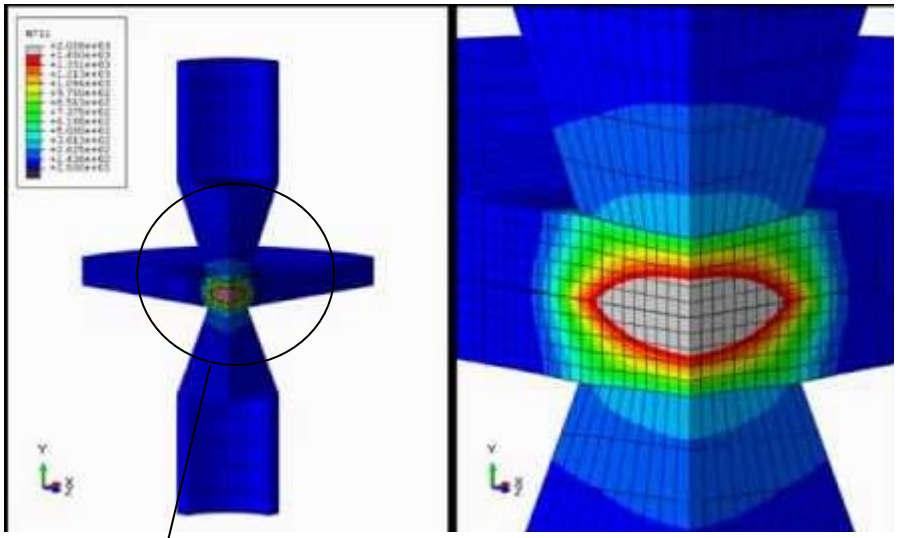


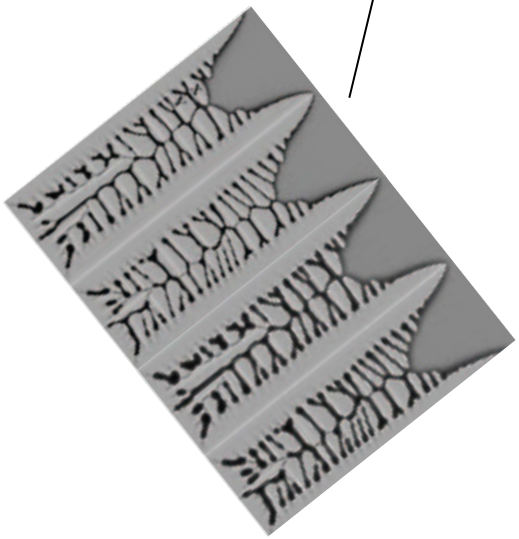
Condition of pressure welding:

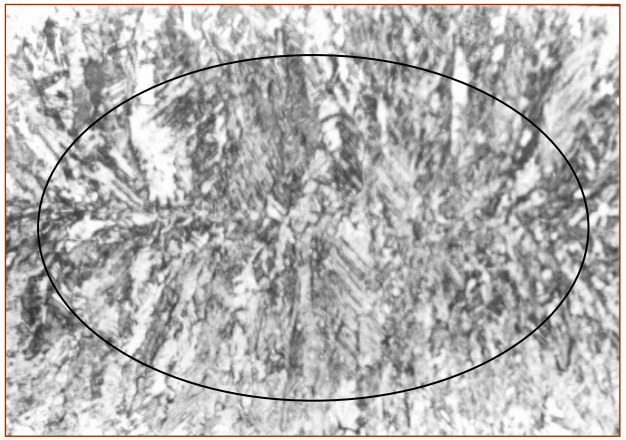
l ⟶ a ..... orientation difference ⟶ 0°



Crystallization under force creates the weld.



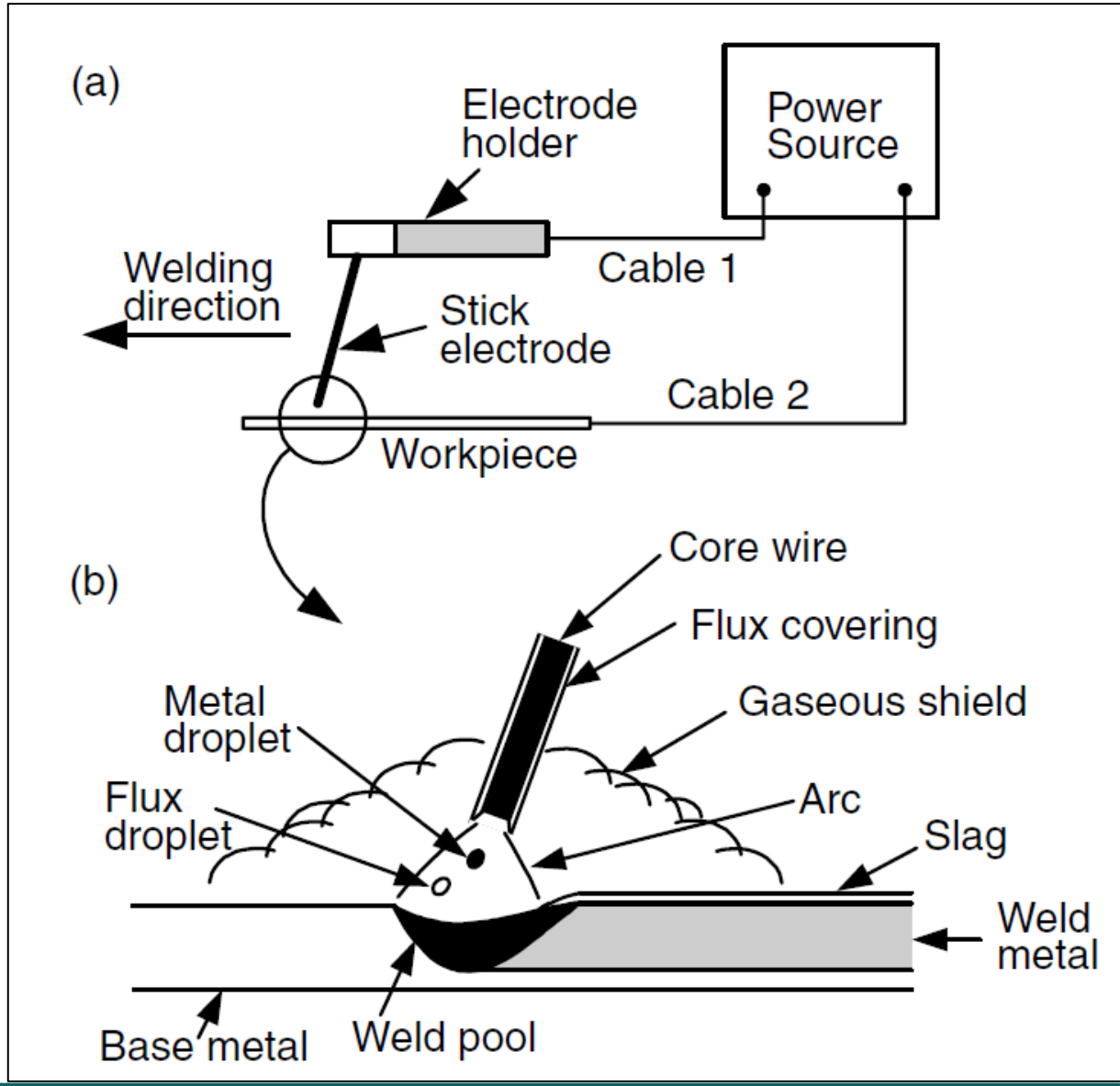




Higher joint strength

Basic manual processes

Manual metal arc welding



Roles of the flux covering

- Stabilizing the arc (K, Na, Ca decreases the emission energy and the ionization potential)
- Evolving gas (organic matters, for example cellulose $(C_6H_{10}O_5)_n$ and from $CaCO_3$)
- Deoxidizing, denitridizing (Mn, Si, Al, V, Ti, etc.)
- Alloying (alloys depending on base material, in the form of ferro-alloys as Fe-Si, Fe-Ti, Fe-Cr etc.)
- Making up the slag (from rutile, from organic materials, from SiO_2 and MnO etc.)
- Decrease the cooling speed, metallurgical processes
- Increase the melting rate (melting efficiency can reach 220 %)

Applications based on the type of flux covering

- Acid flux electrode should be applied when the welding position is simple but the penetration to be reached is high.
- Cellulose flux electrode is used for tubes root pass welding (transmission line tubes).
- Rutile flux electrode is used for „around the house” type of works and when the expected mechanical properties are at medium level.
- Basic electrodes are used for constructions where mechanical properties are important and high.

Nowadays flux mixtures are used as electrode covering

Welding parameters

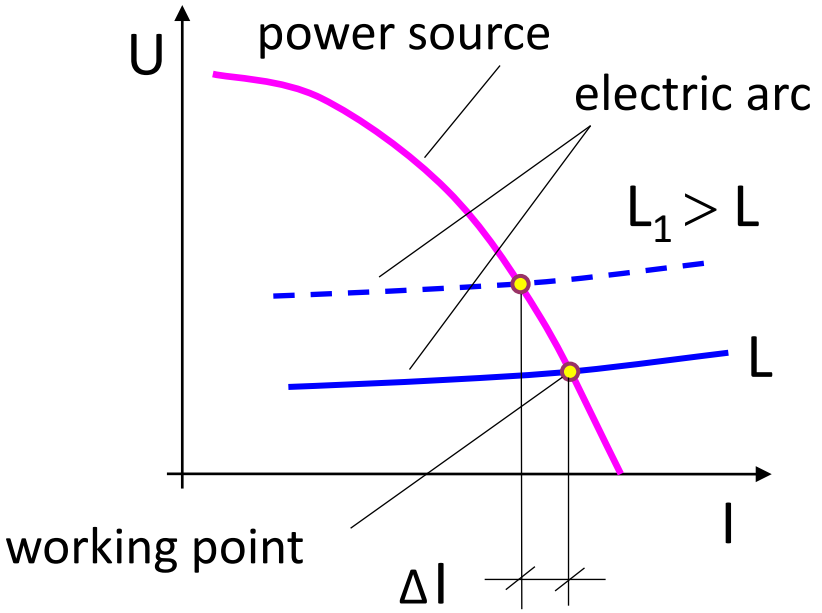
- Wire diameter: d_e=1,5 ÷ 6 mm
- Current: I = 30 ÷ 500 A (I = (30÷60) x d_e, A)
- Arc voltage: U = 20 ÷ 50 V (U = 0,04 I + 20, V)
- Welding speed: v_{weld}= 80 ÷ 200 mm/min
- Pull out length: L_{pull}= 100 ÷ 400 mm.

Pull out length means the length of the weld seam that can be made with the efficient length of the electrode.

By the pull out length, the cross section of the weld and the heat input (welding speed) can be well controlled.

DC and AC current can be applied produced by:

- Welding transformers
- Welding rectifiers
- Welding generators



Characteristics: internal control

Application of manual arc welding

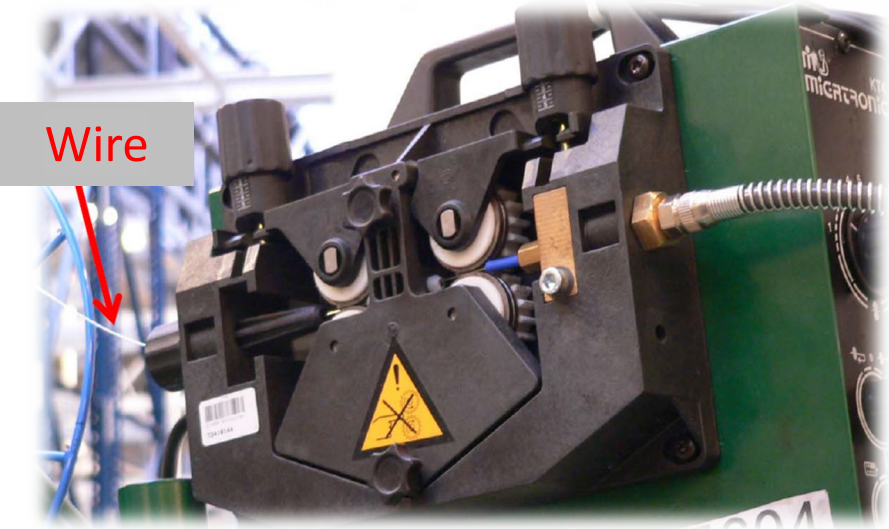
- Widely used in every segment of the industry, because of its simplicity, and low price. Practically there is suitable electrode for every type of material, easy to learn the procedure and does not require high capital investment.
- On-site welding
- For surfacing and repair welding most welding materials are available in the form of flux covered electrodes.
- Disadvantage is the low melt-off efficiency, the rather strong contribution of the human factor, and it is hard to apply for non-ferrous metals.

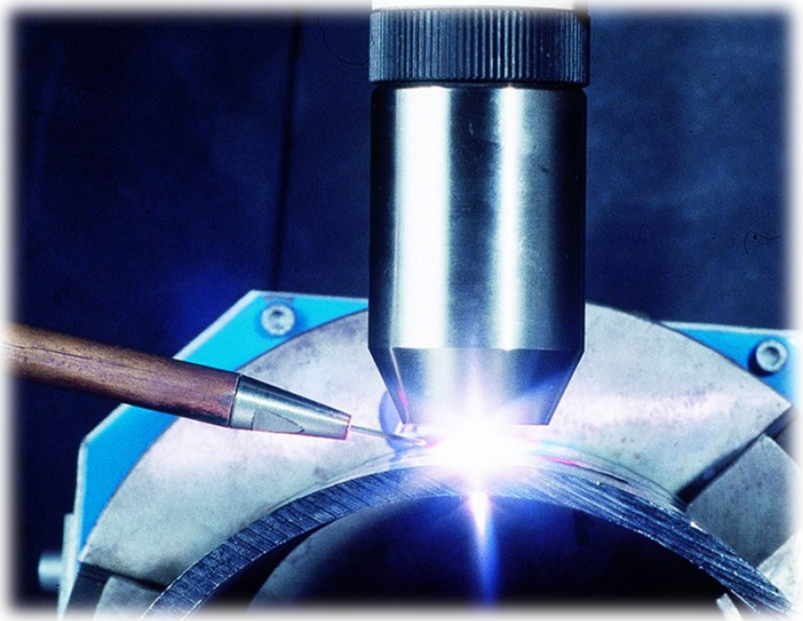
MMA welding

Basic gas shielded processes

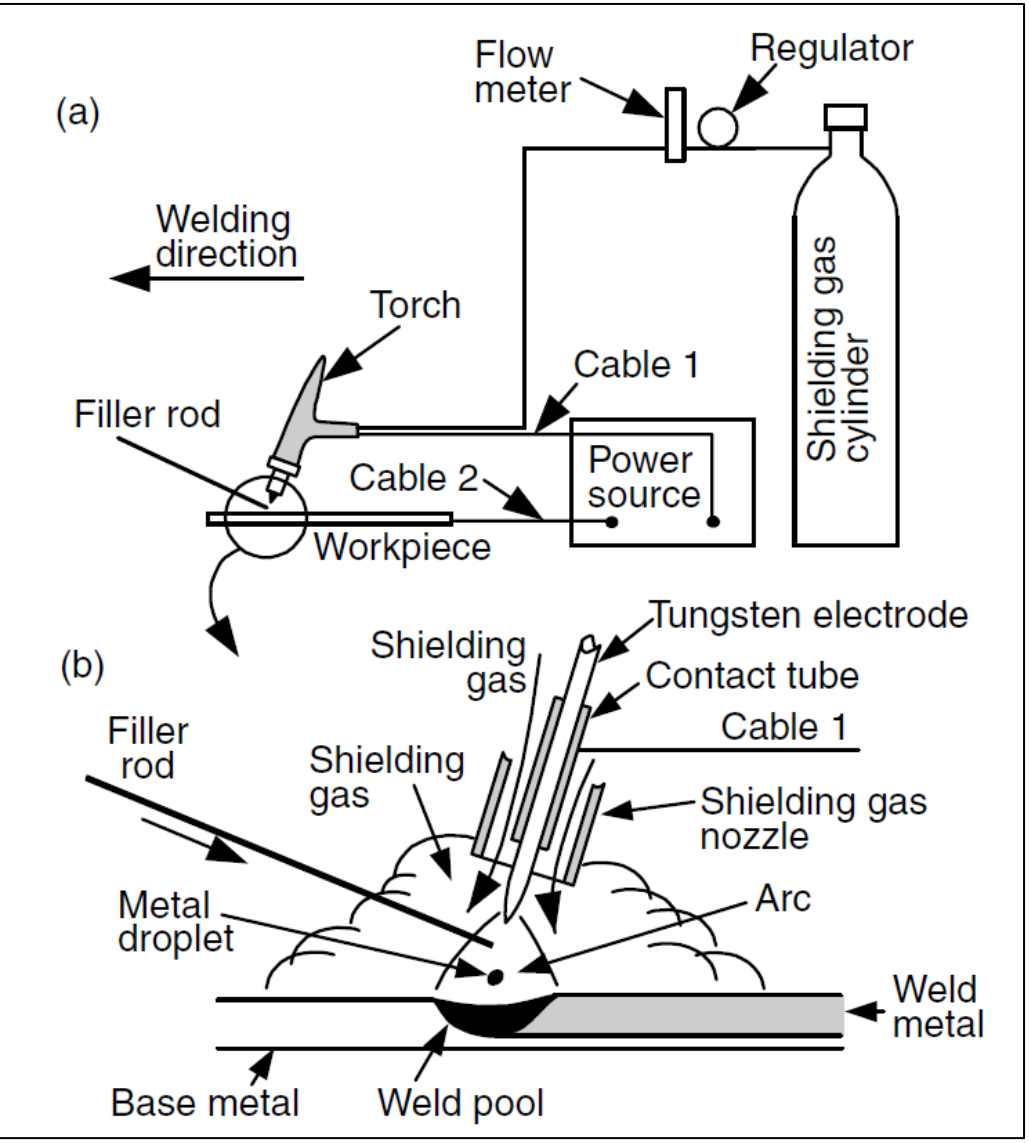
- Gas tungsten arc welding
- Gas metal arc welding
- Plasma welding

These are semi-automated processes (if the filler material feed is automated).



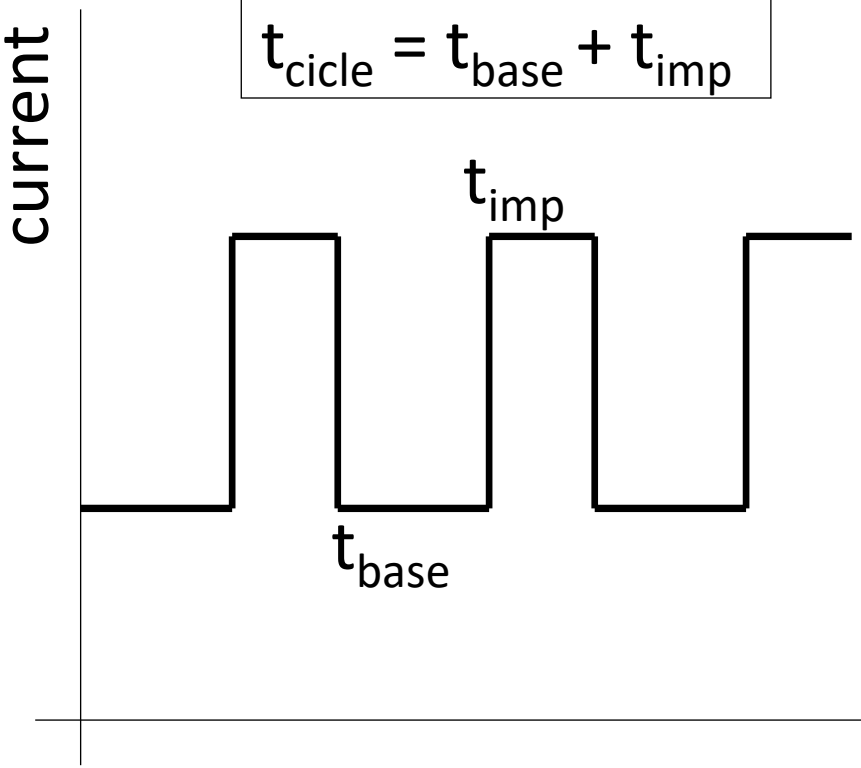


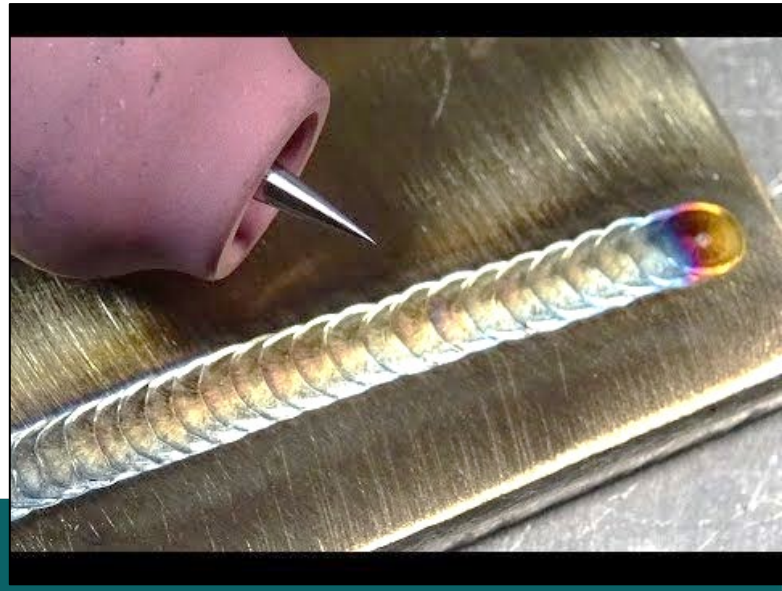
Gas tungsten arc welding (GTAW)



Applying impulse welding

$$t_{cicle} = t_{base} + t_{imp}$$

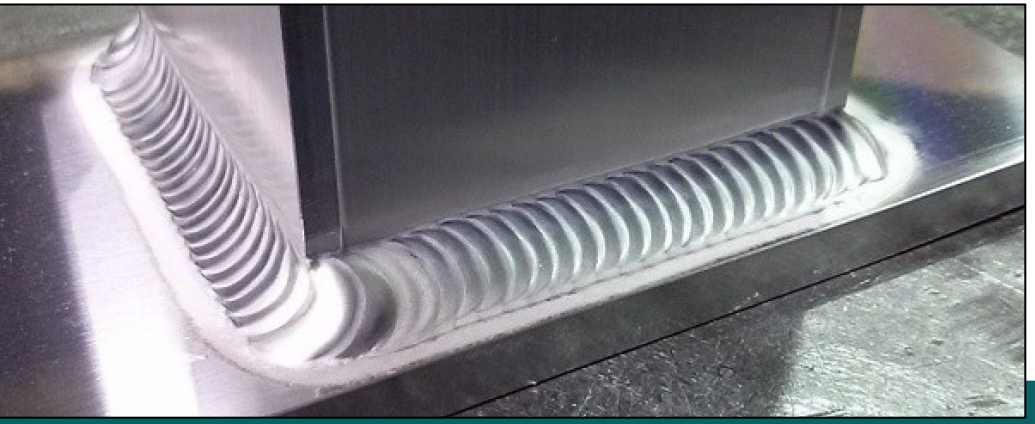




Impulse welding enables well controlled heat input.

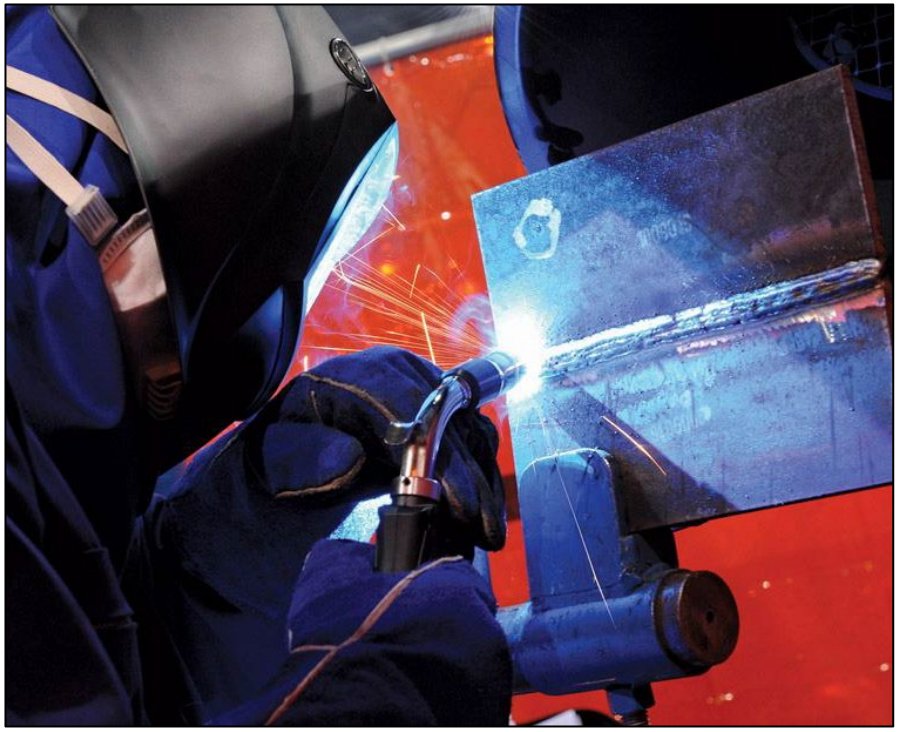
GTAW applications

- Non ferrous- and light metals, high alloyed steels (tool repairs and pile up welding, corrosion resistant steels). Cylindrical welded seams on tubes, also for root pass at unalloyed and low-alloyed steels.
- Application constraint:
  - Small melt-off efficiency
  - Needs highly qualified personnel with practice.
  - Cannot ensure proper gas shielding at windy places.



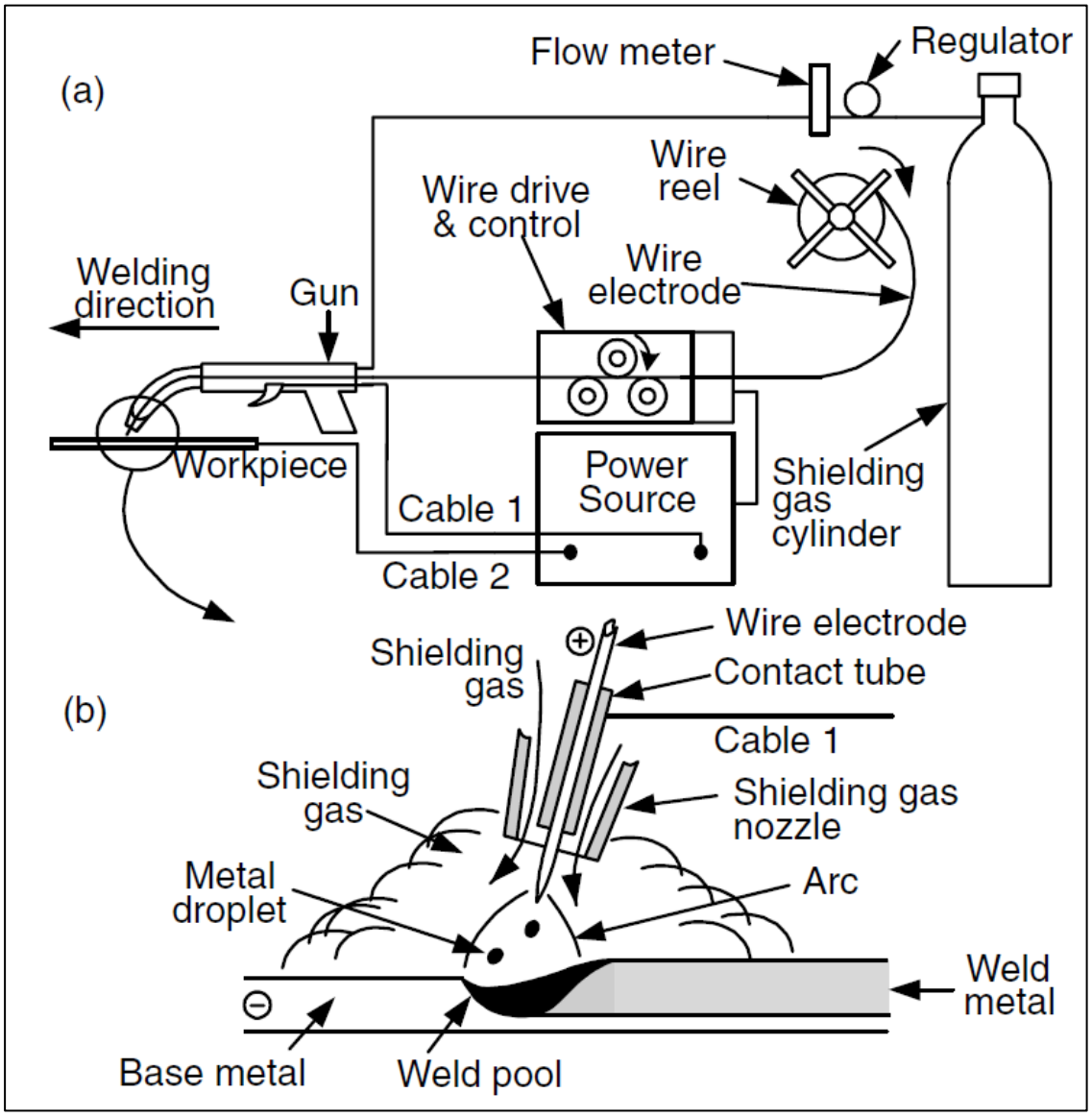
TIG welding of titanium

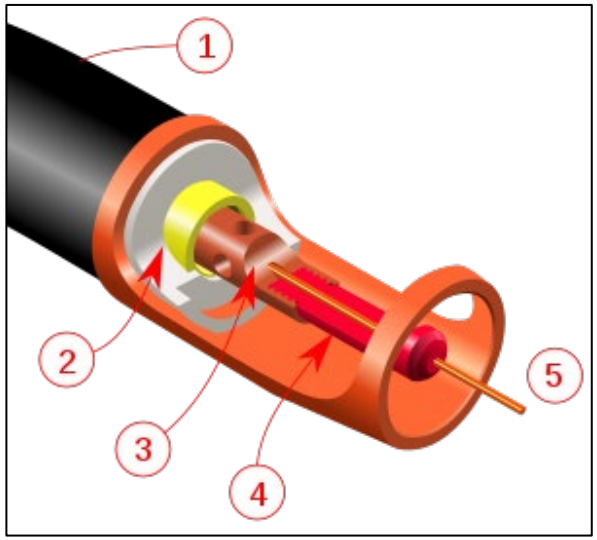
Gas Metal Arc Welding (GMAW) processes



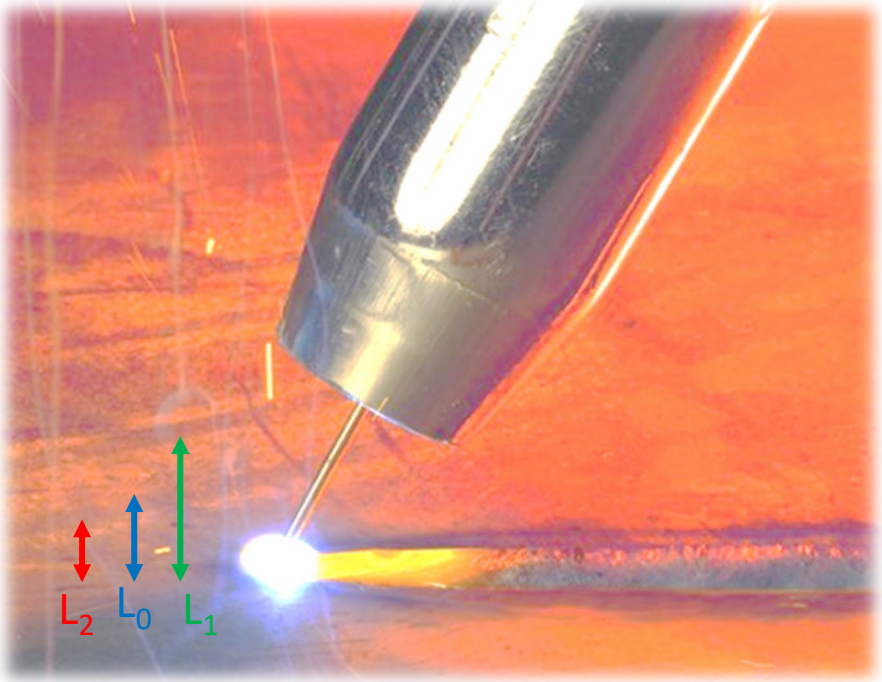
Metal active gas welding (MAG)
Metal inert gas welding (MIG)
Flux cored arc welding (FCAW)

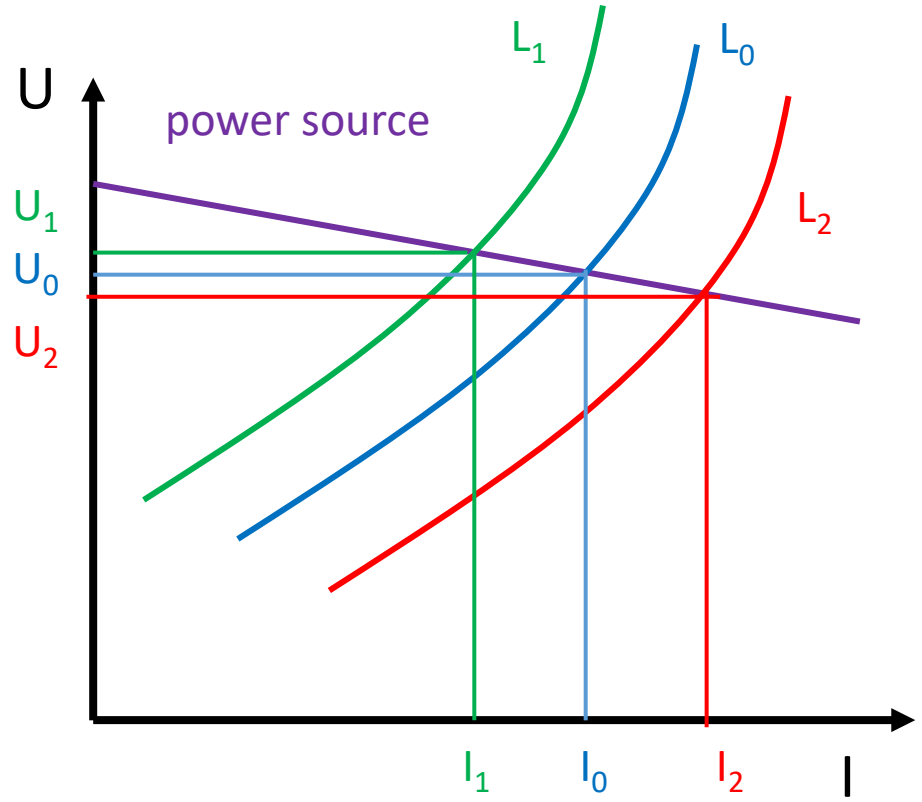
Gas shielded metal arc welding





Power source for GMAW





$L_2 < L_0 < L_1$

GMAW application

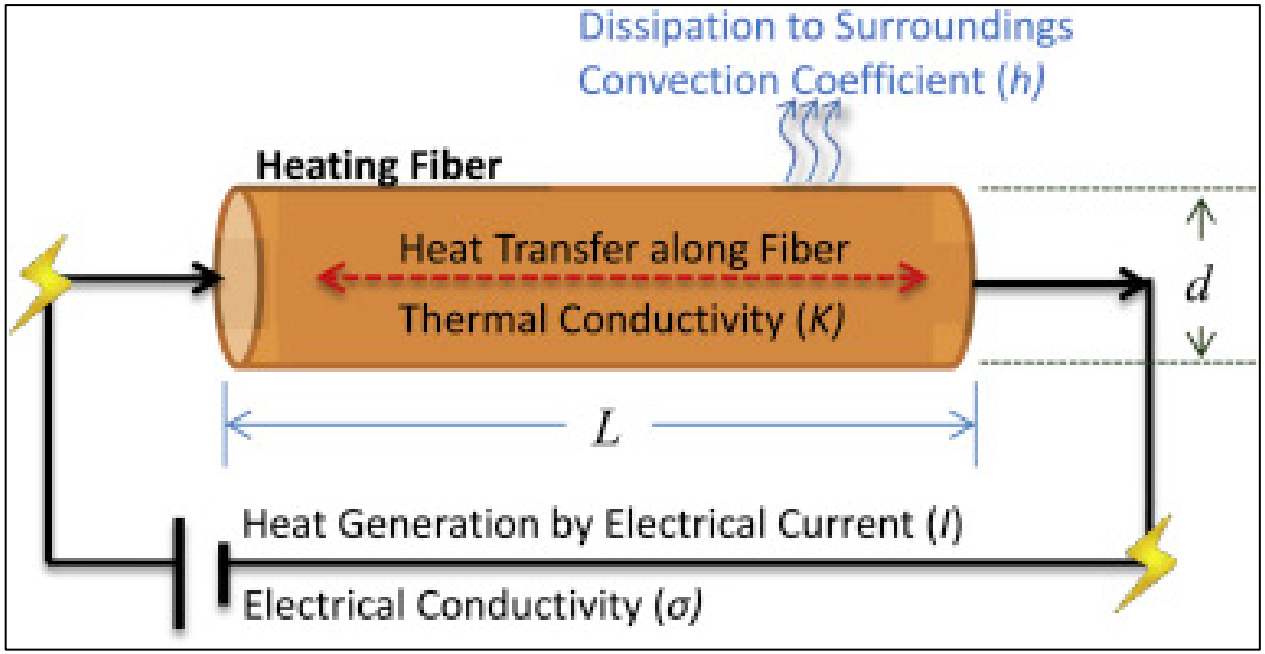
- **CO_2 shielding gas**
  - -Unalloyed and low alloyed mass steel construction
  - - DBTT = 0 °C
- **MAG**
  - - Mass steel construction DBTT = - 20 °C
  - - Robot supported operations
- **Flux cored wire**
  - - Mass steel construction DBTT = - 60 °C
  - - High alloyed steels, surfacing
- **MIG**
  - - Non-ferrous and light metals
  - - High alloyed steels, surfacing

Resistance welding

Resistance heating

- The Joule heat is generated by the current running through the work pieces (**direct heating**) and this heat is proportional with the resistance (R) and the current (I):

$$Q = \int_0^{t_h} RI^2 dt$$



- The second option is to apply induced current, called **indirect heating**.

Resistance welding: advantages and applications

- Workpiece dimensions between wide limitations:
  - Overlapping plates: s = 0,005 … 30 mm
  - Butt welded rods: D = 0,01 … 350 mm
  - Crossing rods: D = 0,01 … 80 mm
- Almost every material can be welded
- The welding process is fully mechanized, well controllable and can be automated.

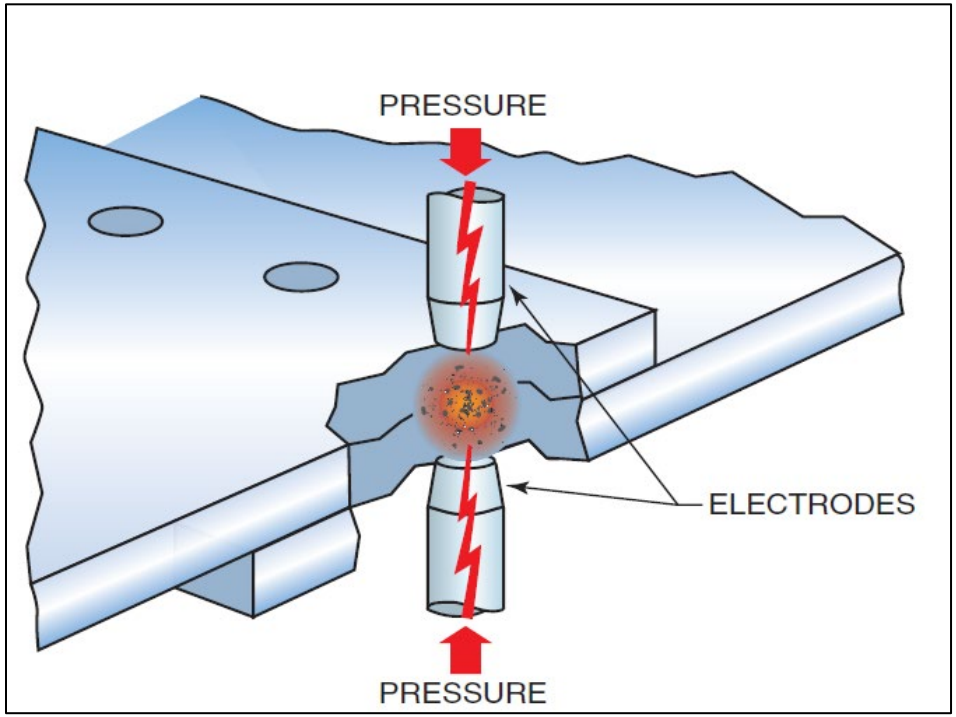
Resistance welding: advantages and applications

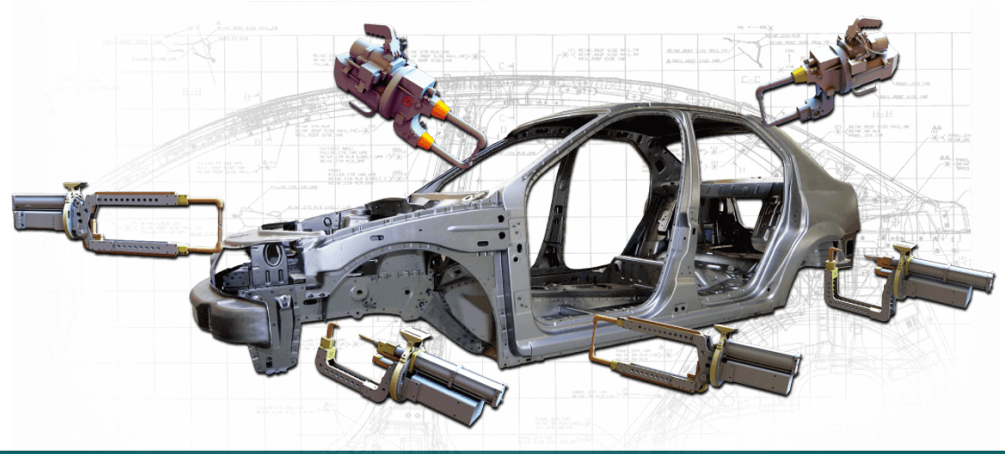
- Welding quality is high and stable
- Heat affected zone is small, so the microstructure change and remaining deformation is negligible
- High productivity
- Material and energy saving is an additional advantage.

Disadvantages

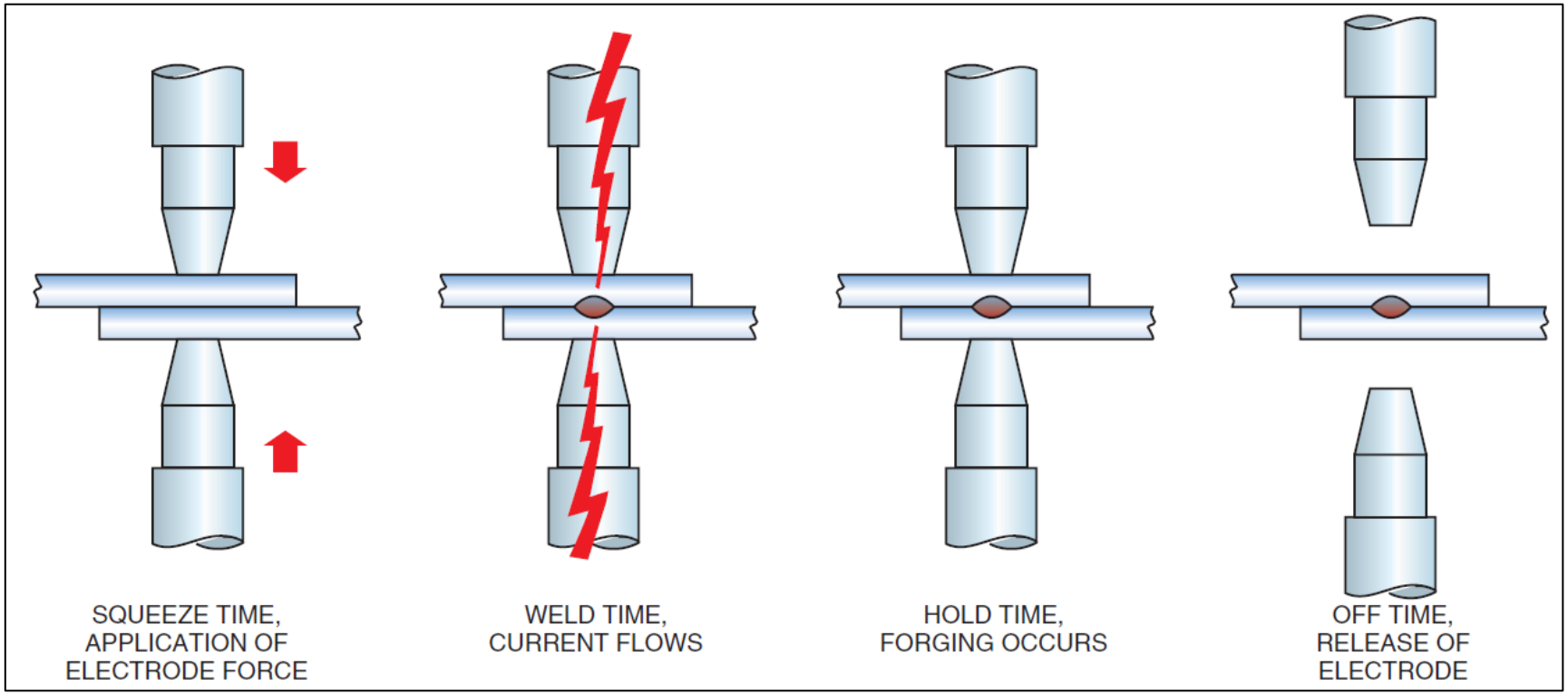
- Expensive welding equipment
- Equipment calibration, setting and maintenance needs highly qualified personnel
- Big amount of scrap when settings are incorrect
- Problem with the mechanical characteristics in some cases.

Resistance spot welding





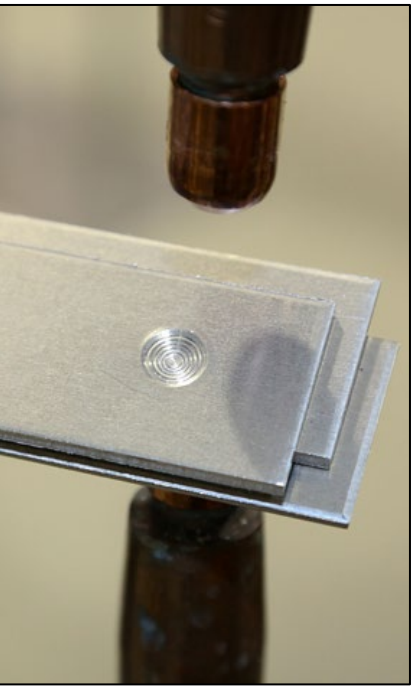
Process of creating a welded spot

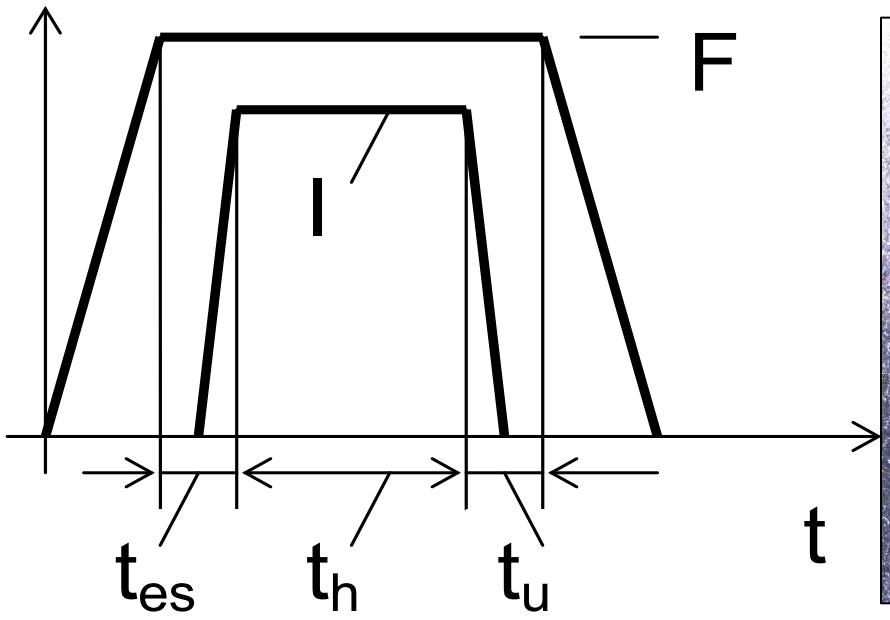


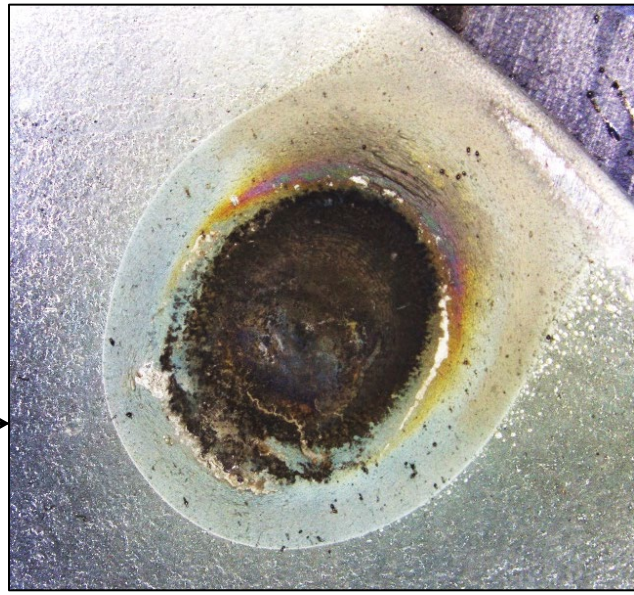
The top electrode approaches the work piece, electrodes are pressed to the work piece, after the preset time the current flows, the material starts to melt in a lens shaped volume.

The melted volume is increasing, if the current is on for too long time, the melted material can be spattered, after the proper time and post keeping the top electrode moves away.

Simple working order







Pressing the electrodes onto the work piece (F), presetting time (t_{es}) has passed, the current (I) is turned on, after the welding time has expired (t_h) the pressure is kept for the post keeping time (t_u). Main welding parameters are I, F, t_h , the pre and post keeping times are supporting parameters.

RSW automotive industry

Thank you for your attention

References

https://www.youtube.com/watch?v=hWqLM7wz61g

https://www.youtube.com/watch?v=MAVPabtSvAA

https://www.youtube.com/watch?v=QEWEMCwSMuw

https://www.youtube.com/watch?v=7R2JtlcOfBo

https://www.youtube.com/watch?v=uxViZYNoqcA

https://www.youtube.com/watch?v=N5AYZxsnDuM

https://www.youtube.com/watch?v=Zc3Fu1AVCjc