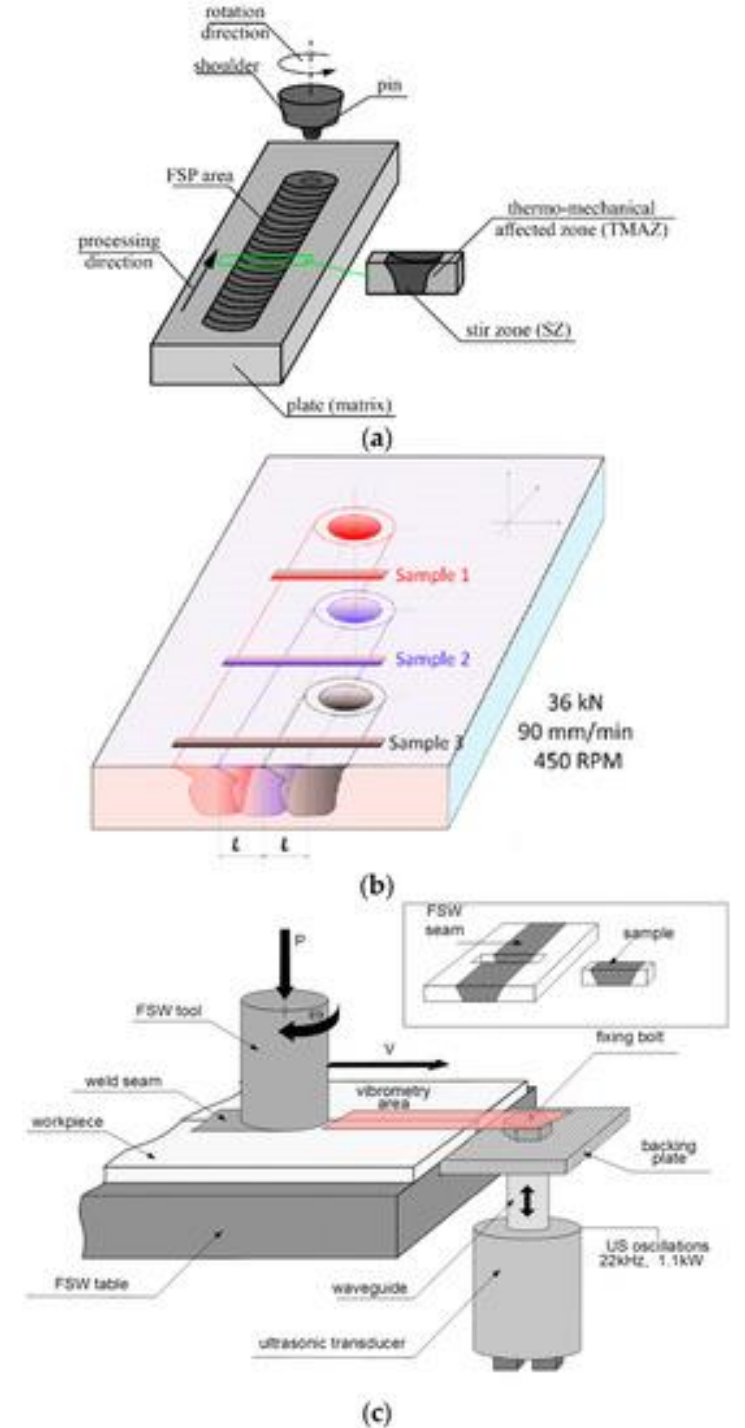


Friction Stir Processing (FSP)

Friction stir processing technology:

- is performed at temperatures below the melting temperature of base alloys.
- is relatively new and is based on the physical principles of friction stir welding (FSW)



- **Advantages:**

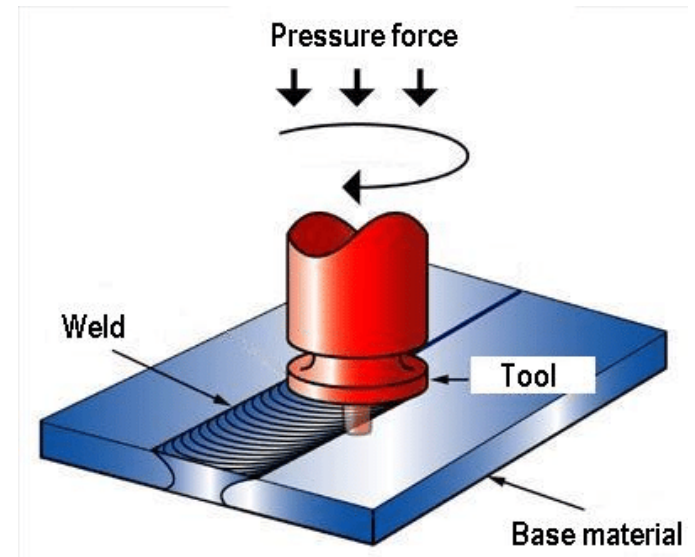
(1) FSP is a solid-state, one-stage processing technique that provides grain refinement, strengthening, and structural homogeneity without changing the shape and size of the processed metallic material;

(2) the microstructure and mechanical properties of the processed parts can be easily controlled by varying the process parameters;

(3) the method is both environmentally friendly and energy efficient. FSP has greatly evolved over recent decades and has found many practical and scientific applications.

Principles

- evolved from the friction stir welding technology and involves similar processes and principles
- the friction-heated and plasticized metal is subjected to severe plastic deformation by stirring, which results in obtaining a homogeneous recrystallized fine-grained microstructure.
- The tool rotates at a high rate and then is plunged into the workpiece under axial force until the tool shoulder contacts the workpiece surface.
- Friction between the tool and the workpiece produces a large amount of heat.



- As the temperature rises due to frictional heat, the base metal softens in the processing zone and undergoes severe plastic deformation while being entrained by the rotating and traversing pin.
- This is the basic principle of modifying metallic materials by FSP, resulting in the formation of a subsurface gradient structure in the material via grain refinement and microstructural homogenization.

Process Parameters

- The main FSP parameters are the tool rotation rate, traverse speed, tool tilt angle, pass time, tool geometry and size, and axial force on the tool.
- The temperature in the processing zone: from $0.6 T_m$ to $0.9 T_m$.
- FSP crush and dissolve agglomerates of reinforcing particles introduced into metal matrix composites.
- FSP allows healing the metal defects such as porosity, cracks, etc. and modifies the alloy microstructure by crushing large matrix grains, second phase particles, and dendrites in cast alloys.
- second phase or reinforcing particles are homogenized or uniformly distributed in the metal matrix.