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Modular tool for friction stir welding and processing

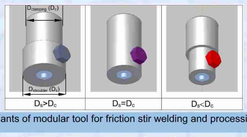
Patent application No. RO 138013 A2 (A/00557/12.09.2022)

Author: Lia-Nicoleta Boțilă

Friction stir welding (FSW) and friction stir processing (FSP) are innovative and environmentally friendly solid state joining / processing processes, based on frictional heating and plastic deformation of the materials to be welded / processed, produced by the interaction of a non-consumable rotative tool with the surfaces to be joined / processed. The process temperature is below the melting temperature of the materials to be welded / processed.

Object of the invention:
The development of modular tools for friction stir welding and processing FSW/FSP, made of interchangeable and reusable elements. The combinations between these elements will generate, quickly and at lower cost, a multitude of variants for modular tools.

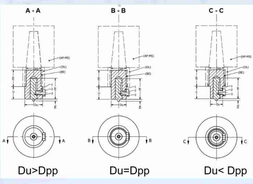
Current technical situation:
The tools used for friction stir welding/processing have various geometries and are generally a monoblock design, being made of sintered tungsten carbides or various types of steels. When the tool is damaged, it will be completely replaced, involving costs related to higher tool material consumption, labor costs and the time required to make a new tool.



Variants of modular tool for friction stir welding and processing

Various tools for friction stir welding and processing

The technical problem solved by invention:
- a modular tool for FSW welding / FSP processing, having a special construction, made of interchangeable and reusable elements for various applications, which solves the problem of high costs of tool materials, labor and time required to make tools in monoblock construction;
- a multitude of types, sizes and geometric configurations of FSW welding / FSP processing tools for various applications, made quickly and with lower costs, by combining interchangeable and reusable elements.



Description of the modular tool:
1 - tool body, provided with a clamping part (PP) and a shoulder (U);
2 - tool pin, provided with a fixing part (PF) and an active part (PA);
3 - screw-type clamping element.
The clamping part (PP) allows the tool to be clamped with an elastic bushing (BE) in the working device (DL) mounted on the main shaft (AP-MS) of the specialized FSW/FSP machine. The working device (DL) can be provided with a set of interchangeable elastic bushing (BE), with different inner diameters that allow the mounting of modular tools with different diameters of the clamping area.
The modular tool shoulder (U) has a central hole in the lower part for positioning of the pin (2) and in the lateral part it has a threaded hole where a screw-type clamping element (3) is inserted to fix the pin inside the tool.
The shoulder of the modular tool (U) can have diameter (Du) greater, equal or smaller than the diameter of the clamping part (Dpp) of the tool in the working device (DL), usually 16 - 25 mm.
Sets of the component elements of the modular tool can be made from different materials, with various geometries and dimensions. The diversity of possible combinations of these elements, can generate quickly at a low cost a multitude of variants of modular tools with interchangeable/reusable elements, for various FSW/FSP applications.

Advantages:
- rapid construction of a geometric tool configuration only by assembling specific modules appropriate to the application in which it will be used;
- possibility of quick and easy mounting of the modular tool into an integrated work device on a specialized FSW machine,
- reduction of manufacturing costs for FSW/FSP tool by replacing the one-piece tool with the modular one, with interchangeable elements.
- modular tool may have component elements made of heat-treated steels resistant to high temperatures. Expensive materials (e.g. sintered tungsten carbides) will be used only for the pin of the modular tool, in the case of welding / processing of metallic materials with high hardness, as well as with high plasticizing temperatures;
- efficient use of the welding / processing tool's pin by:
  - the possibility of using a portion of its fixing part in the tool body to restore the geometry / dimensions of the worn active part;
  - the possibility of reusing it to achieve another geometry of the pin's active part, with smaller dimensions, for other applications.

Information: tel. +40 256 491831, fax: +40 256 492797, e-mail: centa@isim.ro, isim@isim.ro

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Adaptive thermal monitoring and control system for friction stir welding and processing

Patent application No. RO 138992 A2 (A/00873/27.12.2023)

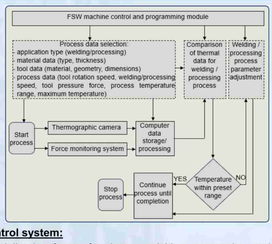
Authors: Lia-Nicoleta Boțilă and Alin-Constantin Murariu

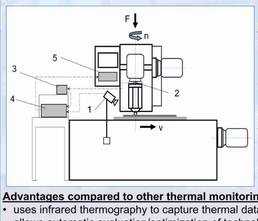
Friction stir welding and processing (FSW) / (FSP) are innovative and environmentally friendly solid state joining/processing processes based on frictional heating and plastic deformation of materials in the welding/processing zone, generated by the action of a rotating tool on the materials to be joined/processed. The process is carried out below the melting temperature of the materials to be welded/processed.

Object of the invention:
Adaptive computerized thermal monitoring and control system for friction stir welding and processing processes. It is an advanced technological solution that uses infrared thermography for continuous and real-time thermal monitoring and control of welding and processing processes, as well as for the evaluation and optimization of technological parameters.

Current technical situation:
There is the possibility of manual/automatic monitoring of the technological parameters of the FSW/FSP processes. However, the possibility of automatic monitoring and control of these processes with a computerized monitoring and control system using infrared thermography is new in the state of the art, has an inventive character and industrial applicability, and was not known prior to the filing date of the patent application.

The technical problem solved by invention:
- the adaptive computerized thermal monitoring and control system of welding/processing processes will contribute to their stability and to the improvement of the quality of welded/processed materials,
- the use of infrared thermography to provide thermal data for the evaluation/optimization of technological parameters and rapid identification of process deviations/non-conformities,
- the possibility of automatic intervention (through feedback connections) to eliminate process deviations/non-conformities, to optimize the values of process parameters (tool rotation speed, welding/processing speed, tool pressing force on the surface of the materials to be joined/processed), to ensure the stability of the process and process parameters.
- offers solutions for real-time thermal analysis of FSW/FSP processes by providing thermal data to a computer interconnected with the control and programming module of the FSW machine, the data being automatically analyzed/compared with the reference data (by types and thicknesses of materials) stored/memorized by this module. In case of deviations, parameter correction is automatically performed to achieve thermal stability of processes.





Description of adaptive monitoring and control system:
1. infrared thermographic camera (with specialized software for data acquisition, processing and analyzing thermal images), mounted on a support on the FSW machine, focuses the image from behind the tool, in the welding/processing direction
2. force monitoring system using a force cell integrated on the main axis of the FSW machine in the motor drive area that ensures the rotation of the welding/processing tool
3. datalogger for data acquisition from the force cell (2)
4. computer connected with (1) and (3), allows the storage and processing of data regarding the temperature from the work processes and the pressing force of the tool on the surface of the materials to be joined/processed,
5. control and programming module of the FSW machine (where the reference data is stored), interconnected with (4).

Advantages compared to other thermal monitoring and control systems:
- uses infrared thermography to capture thermal data, providing precise and detailed information about the temperature distribution in the work area;
- allows automatic evaluation/optimization of technological parameters, ensuring thermally stable processes and the quality of welded/processed materials;
- easily integrates into specialized FSW welding/FSP processing machines, being compatible with different types and sizes of machines;
- is easy to use and does not require specialized operator training.

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Process for obtaining a hybrid structure reinforced/strengthened with amorphous materials/flat ribbon

Patent application A/00299/11.07.2025, OSIM București

Authors: ***Emilia DOBRIN, Gabriela-Victoria MNERIE, Denis Andrei PREDU, Lavinia-Ileana SÎRBU***

Additive manufacturing of thermoplastics using FDM technology is a modern method used in advanced technical fields. The process involves depositing molten material to create three-dimensional objects. The use of ultrasound is an effective method for improving the quality of the FDM process. It helps to strengthen the bond between the polymers used in the printing materials, increasing the cohesion and strength of the structures obtained.

Object of the invention:
obtaining a finished product with exceptional mechanical properties, high stress resistance, extended durability, and a smooth surface, without the need for complex further processing.

Current technical situation:
The problem of strengthening or reinforcing certain plastics, most of which do not incorporate: 3D-printed filament made of composite materials (e.g., reinforced polymer) or amorphous tape (flat tape) with remarkable magnetic, electrical, and mechanical properties, or stable ultrasonic compaction is not performed to obtain a hybrid final product with a finished surface and increased strength.

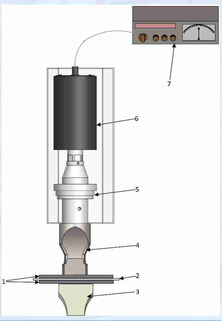

Fig. 1. Diagram of ultrasonic wave equipment in the reinforcement/armoring process

The technical problem solved by invention:
The technical problem solved by the invention consists in obtaining a composite material with mechanical strengths superior to those of the printed material with reinforcement, and due to their joining with ultrasonic energy, the layers of the new material will be compressed, making the filament layers compact, and the surface of the final layer becomes finished and smooth without the use of any other process.

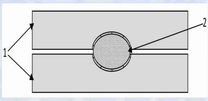

Fig. 2. Representation of reinforced/armored composite structures

Description of the new device:

- Figure 1 schematically shows the two 3D printed parts (1), between which the amorphous reinforcement (2) is inserted, resulting in a hybrid structure;
- Figure 2 schematically illustrates the placement of the assembly on a workbench (3) and the elements of the ultrasonic equipment: the generator (7), the transducer (6), the booster (5), and the sonotrode (4), used for welding/compacting with ultrasonic energy.

Advantages:

- increased mechanical strength by creating a hybrid structure with the integration of an amorphous metal strip between two 3D printed parts;
- smooth and cohesive surface when welding by ultrasonic vibration, which compacts the polymer micro-layers and reduces the spaces between layers;
- efficient and fast manufacturing process thanks to the combination of 3D printing and ultrasonic welding.

Information: tel. +40 256 491831, fax: +40 256 492797, e-mail: edobrin@isim.ro, centa@isim.ro

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Hydrophobic anti-reflective - antistatic double layer deposition system for energy efficiency optimization

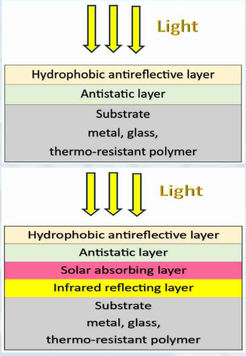
Patent application No. A/00239/12.06.2025

Author: **Alin-Constantin MURARIU**

The invention consists of a dual-layer coating system (a hydrophobic antireflective layer and an antistatic layer) applied on glass or metal substrates, optionally combined with additional functional layers such as solar-absorbing or infrared-reflecting coatings.

The *lower antistatic layer*, based on a sol–gel network doped with ionic compounds, cationic polymers, or conductive nanoparticles, dissipates electrostatic charges. Antistatic dopants (0.1–5 wt.%) may include finely dispersed ionic molecules (e.g., potassium salts, quaternary ammonium salts) or conductive nanoparticles such as fluorine-doped tin oxide (SnO_2:F), which provides both transparency and electrical conductivity.

The *upper hydrophobic antireflective layer* prevents dust adhesion and enables self-cleaning. Its antireflective effect is achieved by controlling porosity and refractive index, using methylated silicon precursors such as tetramethoxysilane (TMOS), methyltrimethoxysilane (MTMS), or similar compounds in a porous SiO_2-based network. The presence of $–CH_3$ groups ensures a high-water contact angle (>120°), while thickness and porosity are adjusted to optimize antireflective performance. The precursor–solvent–catalyst ratio is carefully tuned to balance deposition viscosity and hydrophobic functionality.



Advantages

- *Reduced reflection and minimal material use*: Thin films (50-300 nm) lower raw material consumption and production costs, while their low refractive index increases solar spectrum transmittance and the efficiency of optical and photovoltaic devices.
- *Dust accumulation prevention:* The lower antistatic layer with ionic dopants or conductive nanoparticles dissipates electrostatic charges, reducing dust attraction.
- *Versatile and cost-effective fabrication:* Compatible with existing production lines, using moderate thermal treatments (300-400°C) and applicable on glass, metal, or heat-resistant polymers.
- *Broad application potential:* Usable in energy (solar panels, heliostat mirrors) and industrial/automotive surfaces exposed to dust or electrostatic loads.
- *Durability and reliability:* The dual-layer film ensures strong adhesion, UV resistance, temperature stability, and mechanical abrasion resistance, maintaining optical and antistatic properties over time, thus reducing maintenance costs and improving energy system performance.

Information: tel. +40 256 491831, fax: +40 256 492797, e-mail: amurariu@isim.ro, centa@isim.ro

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ULTRASOUND ACTIVATION DEVICE FOR FLOWING OR LIMITED VOLUME LIQUID MEDIA

Patent application No. RO 138756 A0 (A/00456/01.08.2024)

Author: **Nicușor-Alin SÎRBU**

Homogenization and dissolution of biological or solid components is used in various techniques for processing liquids in limited volumes or in flow state. It is often necessary to homogenize mixtures of different liquids or to emulsify them. To achieve these processes, mechanical stirring action is used, usually with rotating elements, stirring by vibration, but especially using ultrasound energy for cellular effects due to ultrasonic cavitation, or forcing liquids through the narrow and fragmented spaces of slits arranged in a labyrinth-like manner. In some applications the above procedures are complemented by controlled heating of liquids to accelerate processes due to thermal energy.

The technical problem solved by invention:

The technical problem of the invention is the realization of a device for the homogenizing, emulsifying and dispersing processing of a liquid in a limited volume or in a flowing state in continuous flow by combined ultrasonic, mechanical and thermal action in order to increase efficiency and reduce processing time.

Object of the invention:

The device according to the invention provides an efficient and rapid activation of liquids by the simultaneous superposition of the ultrasonic activation effect, the mechanical activation effect and the heating effect.

Advantages:

- Ensures an efficient and fast activation of liquids by superimposing the ultrasonic activation effect, the mechanical activation effect and the heating effect simultaneously;
- Provides the possibility to adjust activation parameters (ultrasonic intensity, rotation speed, heating temperature);
- Is simple in construction and easy to use.

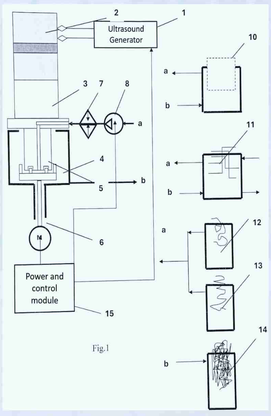

Fig.1

1. *Ultrasound generator*
2. *Ultrasonic transducer*
3. *Wave adaptor concentrator*
4. *Activation enclosure*
5. *Rotating agitator disk*
6. *Variable speed motor*
7. *Heater*
8. *Electric pump*
9. *Inlet*
10. *Collection container*
11. *Continuous-flow installations*
12. *Supply container*
13. *Supply container*
14. *Collection container*
15. *Power and control module*

Information: tel. +40 256 491831, fax: +40 256 492797, e-mail: asirbu@isim.ro, centa@isim.ro

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