

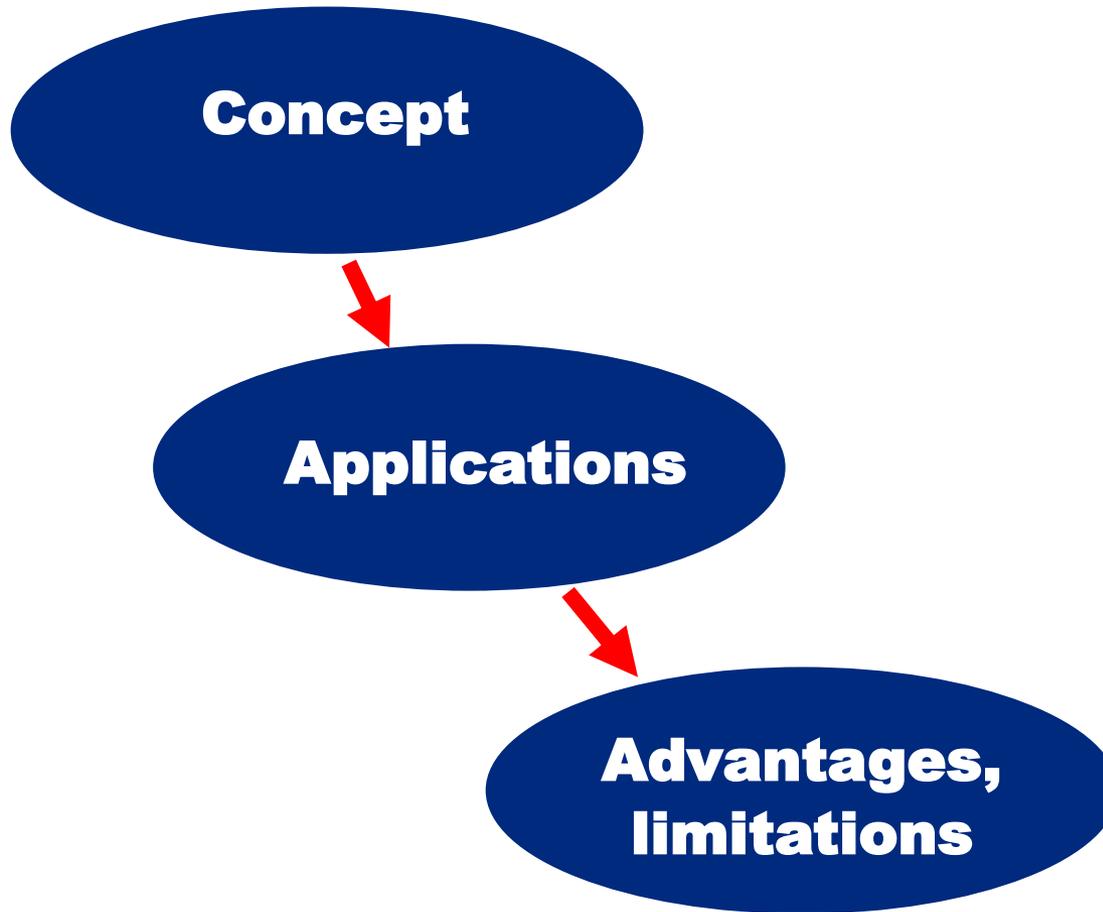
## **Development of FSW head for CNC machine tool: advantages, limitations and applications**

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**Le projet : « FSW sur Machine outil à commande numérique », est cofinancé par l'union Européenne. L'Europe s'engage en Bretagne avec le Fond de développement Régional**





Gantry machine



Industrial robot



FSW head on CNC machine tool



Investment cost

1995

2005

2015

PRODUCT

INNOVATION



Broche d'usinage seule



Assembly in 15 mins



Disassembly in 15 mins



Tête FSW installée

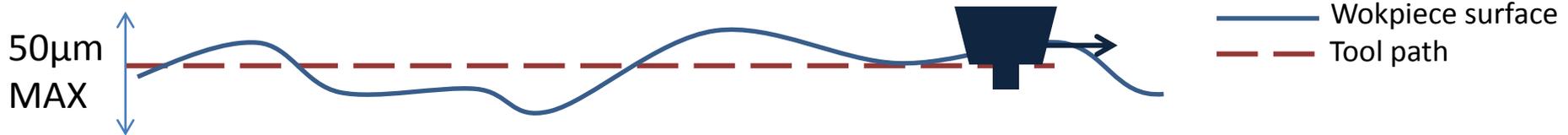
**After disassembly, the CNC machine is unchanged.  
(No hard or soft change of CNC machine)**

- FSW head mounted on 3 to 5 axis CNC machine
- Patent deposited in 2015 by **French governmental organization**
- All FSW functions for industrial use:
  - Force control along the FSW tool axis (**performed directly into the head to not modify the command of CNC machine: universal solution**)
  - Cooling system
  - Protection against the high forces and vibrations during the FSW process **to not damage the bearings of CNC machines**
  - Recording of the Z forging force for quality control



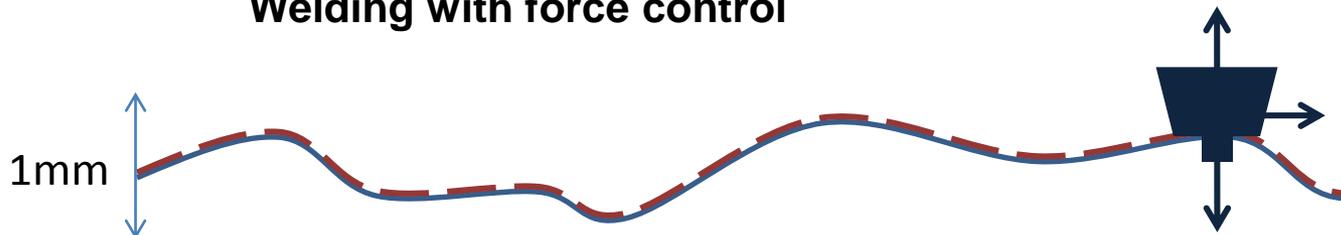
- Tool penetration in the workpiece must be constant to secure the weld quality.
- FSW requires a Z tool position of  $\pm 50 \mu\text{m}$  to avoid an excessive flashing or a poor stirring.

## Welding without force control



- However, the part thickness is not accurate (**extrusion/rolling**  $\sim 0,1 \text{ mm}$ , **casting**  $\sim 0,5 \text{ mm}$ ) + inaccuracy of part positioning (**part positioning**  $\sim 1 \text{ mm}$ , **thermal distortion during welding**  $\sim 0,5 - 2 \text{ mm}$ ).
- The force control solves this problem on CNC machine (1 to 18 kN).

## Welding with force control



- Demonstration of force control on 1-mm step defect



Welding without force control  
(positive step) : **excessive flash**



Welding without force control  
(negative step) : **porosities / wormhole due to the lack of compactness**



Welding with force control:  
**no defect**



## ■ Examples on NC machine integrations

**Hartford  
VMC-1300  
(Fz = 8000 N)**



**Mazak Nexus  
510C  
(Fz = 7000 N)**



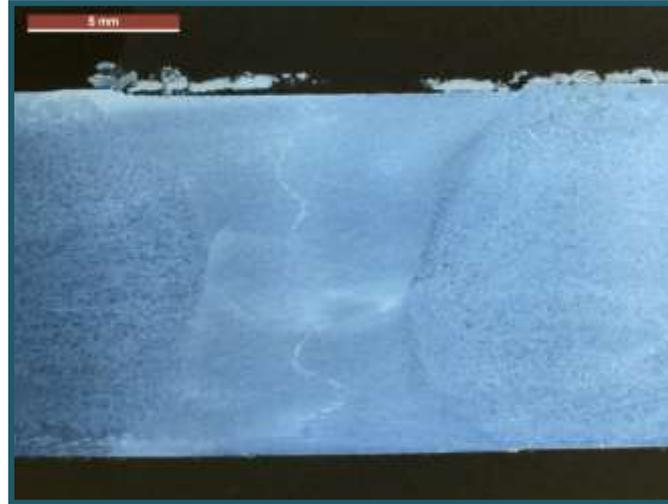
**Hermlé C30U  
dynamics  
(Fz = 8500 N)**



**Vernier  
CV800  
(Fz = 9000 N)**



- Welding to reduce the raw material cost
- Aluminium frame
- Double FSW passes of 12-mm AA6061- T6
- Post FSW machining is carried out directly into the welding jig without disassembly of the parts.



Parts after FSW



Detail of the weld

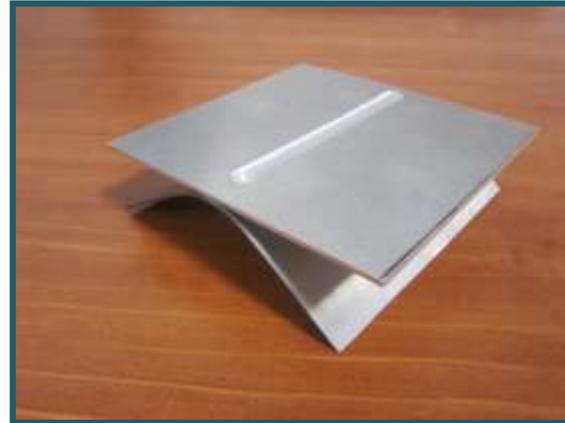


Finished part

- Welding in metal sheet job-shop:
  - Replacement of aluminium resistance welding: reduction of the cost (no electrode wear) and no damage of the back side.
  - Welding of aluminum on steel to replace fastening



**Spot welding: replacement of resistance welding**

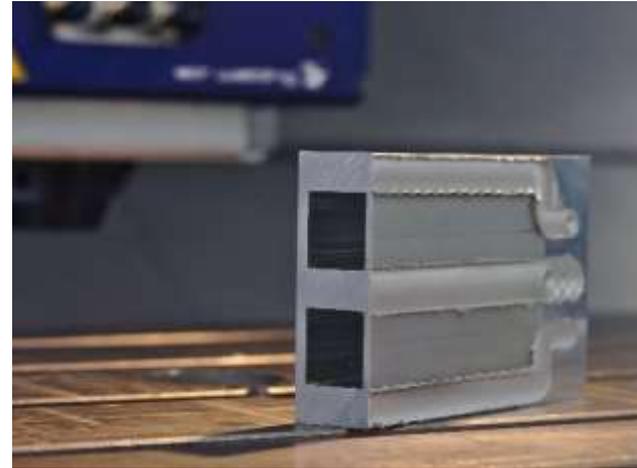


**Lap welding of AA5754-H11 (2 mm) on S235 (1 mm)**

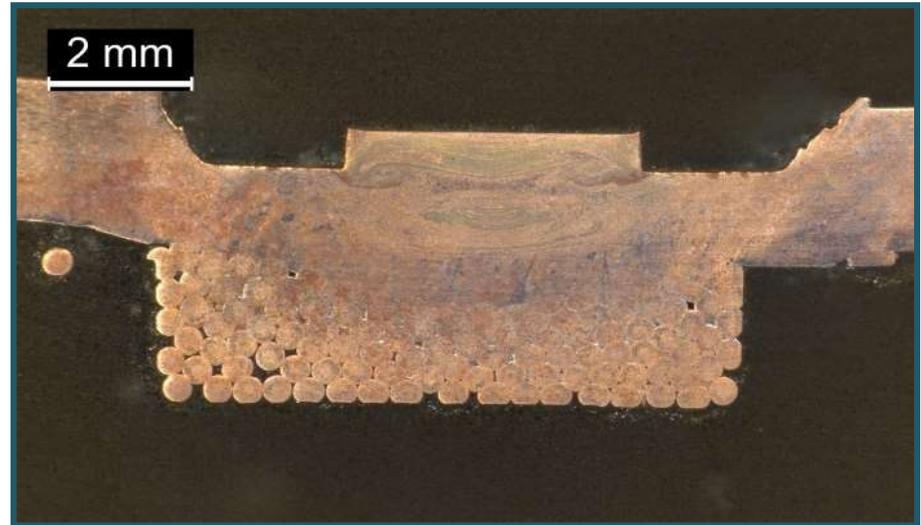


**Bending test**

- Cooling fins or water channels on electronic box



- FSW spot welding of copper bracket on copper wire
- FSW can replace resistance welding or fastening by reducing the electrical conductivity
- The manufacturing cost is lower (no electrode wear in case of welding, no screw or drilling in case of fastening).



Lap welding of copper bracket on copper wire

## ■ Advantages:

- Low cost solution to access to FSW process : most of companies already have a CNC machine. OR: *"my CNC machines are too busy. No problem: I'm going to buy a secondhand 2-m CNC machine for 50k€ !!! "*
- This development is interesting for SMEs having small batches of pieces.
- Development of 12 low volume industrial applications in less than 2 years !
- Improvement of machine flexibility : no hardware or no software modification of the CNC machine. After a 5 min-disassembly, the CNC still unchanged.
- Full manufacturing sequence on a single machine without workpiece displacement: part machining > FSW > finishing operation

## ■ Limitations:

- CNC machine size is limited compared with gantry or robot. Most of the time, the Z axis is 600 mm maximum.
- The 3D capacity is limited compared with robot.
- This technology is complementary to FSW gantry or robot, which are reserved for mass production and/or large 3D components.
- The maximum Z load of the head is 18kN (most of CNC machines have a maximum Z force of 18kN), limiting the maximum thickness in one pass to 15 mm in 6xxx or 8 mm in 7xxx.
- *To reduce the cost doesn't solve problems of clamping system! 50% problems come from the jig.*

# Institut Maupertuis

The Institut Maupertuis is a technological research center in production and mechatronics. The institute guides companies into products and production tools innovation by making skills, production tools and methods available to them.



### Innovative engineering projects

Guidance into collaborative technical focused projects : research of industrial or academical partners, seeking for funding, project management.



### Conseil technologique neutre

Consulting on production technologies and industrial applications : RFID, automation, monitoring, sensors ...



### Conseil en robotisation des procédés

Technical and economical feasibility studies , prototypes. National expert for the RobotStart PME program



### Expertise in laser processes

Industrial consulting, tests on laser platform, qualification, prototypes : Welding, cutting, cladding, 3D cutting, polishing, surface finishing.



### Friction Stir Welding

Expertise in robotic FSW assembly

L'association s'inscrit dans la politique régionale de soutien à la recherche appliquée et à l'innovation. Son pilotage est assuré par des personnalités industrielles locales en partenariat avec l'UIMM Bretagne et le CETIM. L'association est soutenue et subventionnée par l'Union Européenne (Fonds FEDER), la Région Bretagne, le Conseil Général d'Ille et Vilaine et Rennes Métropole. L'Europe s'engage en Bretagne avec le Fonds Européen de Développement Régional.



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