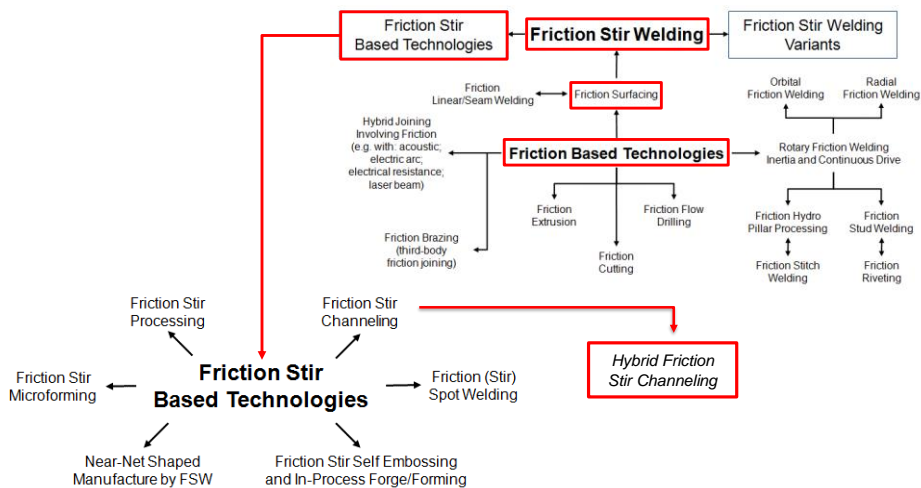


## Features and Case Study of Hybrid Friction Stir Channeling (HFSC)

Heikki Karvinen, Daniel Nordal, Pedro Vilça @ Aalto University, Finland

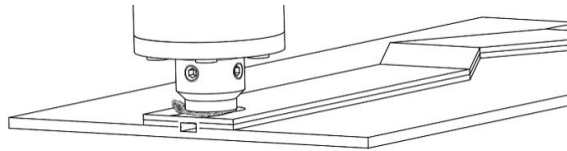
AG52 Meeting  
ESAB, Laxå, Sweden  
30<sup>th</sup> August 2017

## Technological Scope of HFSC



# Hybrid Friction Stir Channeling (HFSC)

- ☞ Solid state method for producing internal, closed channels created simultaneously during welding of multiple metal plates
- ☞ Fully coupled FSWeld + FSChanneling mechanism in ONE action
- ☞ Channels with any path and constant or variable shape along the path
- ☞ Tailor-made channel structures
  - ☞ ...similar or dissimilar materials and sizes
  - ☞ ... overlap and butt joint arrangements



## Historical Scope

2005

2010

2016

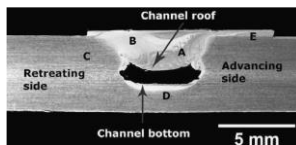
Channeling of a monolithic plate

Welding + channeling

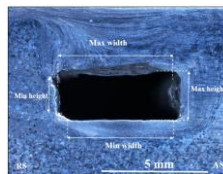
First FSC concept

New FSC

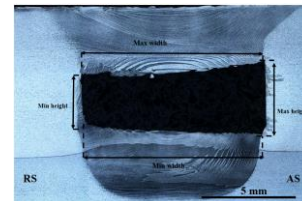
HFSC



Balasubramanian N., et al. (2009) Friction Stir Channeling: Characterization of the Channels. Journal of Mat Proc Techn (209), 3696-3704



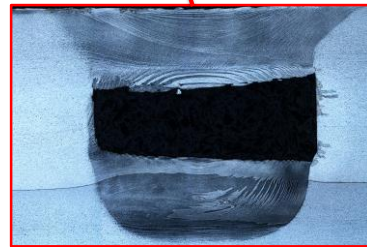
Vidal C., et al. (2013) Effect of Microstructure on the Fatigue Behavior of a Friction Stirred Aluminium Alloy. Procedia Engineering (66), 264-273



Karvinen H., et al. (2016) New Development and Testing of FSChanneling Technique: HybridFSC. 10th Trends in Welding Research, Tokyo, Japan. 376-379.

# New Milestone: Hybrid FSChanneling

P. Vilaça, H. Karvinen, Patent PCT/FI2017/050467:  
One-action simultaneous production of welding  
between multiple components and internal  
closed channels within the processed zone:  
**Hybrid Friction Stir Channeling**



- ☞ Tailor-made Channels...
  - ☞ ...with self-Detachable flash
  - ☞ ...can have any **path**
  - ☞ ...can have constant or variable **shape** along the path
  - ☞ ...can be produced at different **depths**

## Scope Case Study: Heatsinks of Electronics

- ☞ Base stations are **becoming smaller** with increasing data rate → **increase of power** density
- ☞ Higher power levels increase temperatures
  - ⊗ Risk of overheating of components
  - ⊗ Decrease of reliability and life time

...Typical cooling solutions...



Passive cooling  
(cooling fins)



Cooling tubes



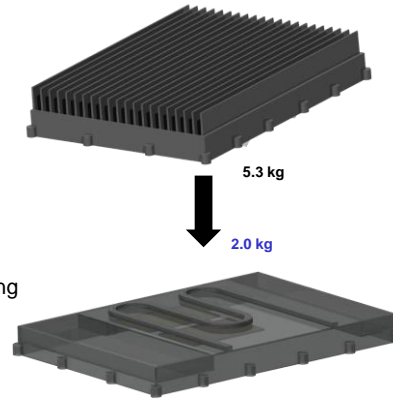
Active cooling  
(fans)



## Motivation

### Case Study: Heatsinks of Electronics

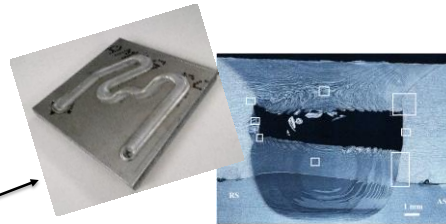
- ☞ Improved cooling capacity → better component reliability
- ☞ *versus* Fans:
  - ✓ cleaner (no internal dust)
  - ✓ lower energy consumption
- ☞ *versus* Fins (passively cooled casing):
  - ✓ Smaller volume → lighter
  - ✓ Less material → economic and less environmental impacts
  - ✓ Easier and more economic casting
  - ✓ Channels made of similar material as the casing
    - e.g. corrosion resistance is not changed
    - easy recycling
- ☞ Produced heat can be recovered and utilized



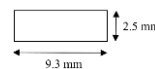
## Case Study: Heatsink Prototypes

### Test Setup and Procedure

- ☞ Aluminum heatsinks made with:
  - **HFSC**
  - **Milled channels**
- ☞ Same channel path: length = 465 mm
- ☞ Same shape (approximately)



Channeling technique	HFSC	Milling
Average channel width (mm)	9.3	9.3
Max channel height (mm)	2.4	2.5
Cross-sectional area (mm <sup>2</sup> )	21.9	23.3

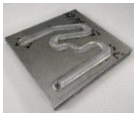


**Sealing:**  
2 mm aluminum plate + 47 screws

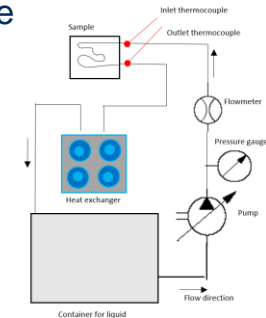
## Case Study: Heatsink Prototypes

### Test Setup and Procedure

#### HFSC



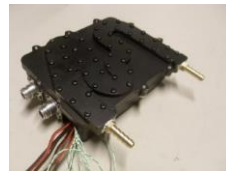
0.399 kg



#### Milled Channels



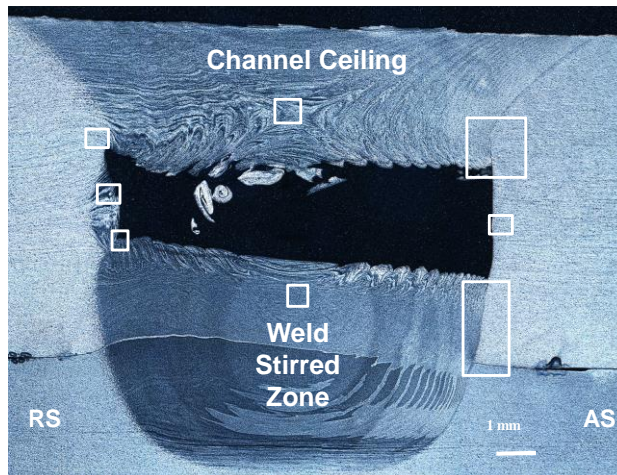
0.512 kg



Sealing: 2 mm aluminum plate + 47 screws

## Case Study: Heatsink Prototypes

### HFSC Characterization: Macrograph Analysis



## Other Features of HFSC: channel path stability

### S-curves and Spirals

↳ Stable channel size and shape in large and small curves

↳ Allows closely spaced channels and more flexibility for channel paths



R8.25

R13.75



Spirals channeled from inside out and outside in

↳ Flash extraction does not affect channel cross-section

## Conclusions

- ☞ HFSC is a feasible technique to produce, in one action only, heatsinks with closed internal channels of large dimensions, with complex path, while joining two plates
- ☞ Both production methods resulted in heatsinks with admissible distortion, easy to assemble to the chassis containing the electronic components
- ☞ Microhardness at *weld stirred zone* is higher than at *ceiling*. But values close to BM
- ☞ High gradient of vertical packed layers of stirred material against the sheared wall @ AS is evidence of good consolidation of the joining mechanisms
- ☞ Heatsinks produced with HFSC presented in overall, better cooling performance when compared with similar channels produced by milling