Benchmarking of FSW and Other Processes for Making Battery Trays of Compact Crossovers

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The battery is one of the main components of an electric vehicle, both in terms of weight and cost. Therefore, material selection and cost-effective manufacturing processes are of key importance in the production of these vehicles. This paper reports on a benchmarking study focussing on material selection and manufacturing processes for compact crossovers like the Volkswagen ID.4 and Ford Mustang Mach-E (Figures 1 and 2). The cost data are educated guesses based on detailed discussions with several manufacturers and should not be interpreted as cast in stone, while the battery tray market is developing very quickly.

Fig 1: Volkswagen ID.4

Fig 2: Ford Mustang Mach-E

Benchmarking of Four Welding and Joining Processes

An aluminium battery tray has been designed in this benchmarking study with similar dimensions to those in the Volkswagen ID.4 and Ford Mustang Mach-E. It should be produced from 17 aluminium extrusion, one aluminium sheet and four brackets by four welding and joining processes, to demonstrate their cost and benefits: Friction stir welding, hybrid laser-MIG, MIG welding and flowdrilling (Figure 3).

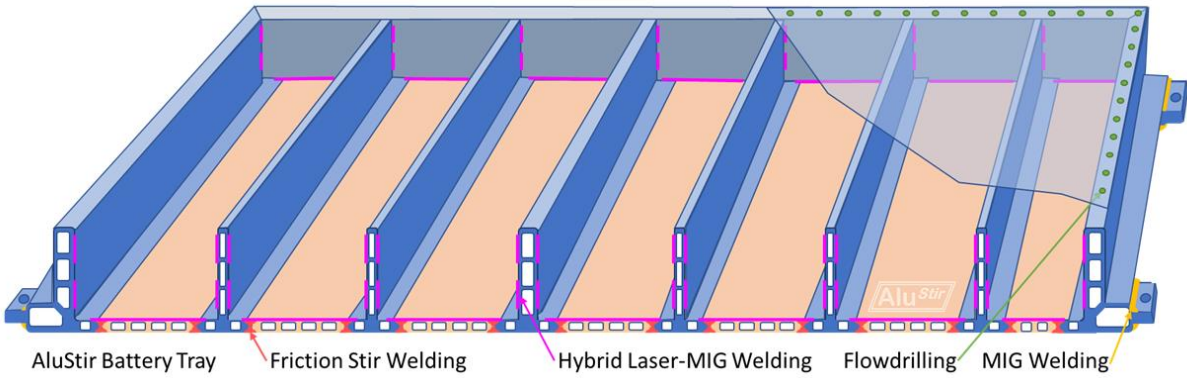

Fig. 3: AluStir aluminium battery tray to be produced by four processes: FSW (red), hybrid Laser-MIG (magenta), flowdrilling (green) and MIG welding (yellow) *© AluStir*

For this benchmarking study the 1300 x 1700 mm floor plate of the battery tray is made from hollow aluminium extrusions which are joined to each other by 14 parallel friction stir welds (Figure 4). Unless the floor plate is water cooled itself, the floor plate needs only to be welded from one side and a mechanical interlock can be used on the other side. Otherwise, it is recommended to weld both sides simultaneously, because it is very time consuming to turn the floor plate around.

The manufacturing costs of battery trays depend significantly on the size of the battery tray, the annual volume and the location of the plant. This benchmarking study is based on producing 1.3 x 1.7 x 0.15 m large trays for 200,000 cars per year in Europe.

Two FSW machines and one materials handling robot are required for achieving a cycle time of 300 sec (Fig. 5). Thus, three welding cells with a total of six FSW machines are needed to achieve a cycle time of 100 sec, as required to produce 200.000 cars per year.

Conclusions

The conclusions of this benchmarking study are as follows:

- Currently, most battery trays are made from aluminium, and the most successful manufacturers use friction stir welding to make them.
- The combination of the four welding and joining processses (friction stir welding, MIG welding, hybrid laser-MIG welding and flowdrilling) require a bespoke machine investment of only 30 Mio € to produce 200,000 aluminium battery trays per year at a production cost of approximately 400 € per car including materials but excluding labour and overheads (Table 1).
- Material combinations of aluminium, steel and plastics might offer further benefits regarding weight saving, crash worthiness and fire protection, if suitable joining processes can be used, to make the required dissimilar material joints.

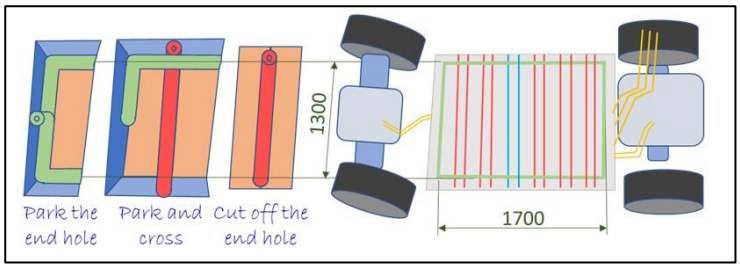

Fig. 4: FSW of a battery tray of a car similar to the VW ID.4

Investment €	Cost per Car €/car	Cost per Metre €/m	
	233.00 €/car	ø 10 €/m	Aluminium extrusions made in Europe from 72 kg alloy AA 6082-T6
	10.20 €/car		Sawing and collating of 17 aluminium extrusions (17 x 0.60 €)
7,500,000 €	15.18 €/car	0.69 €/m	3 friction stir welding cells with 6 FSW machines and 3 material handling robots including wear of FSW tools at 350 €/1000 m
15,000,000 €	30.37 €/car		CNC milling
1,200,000 €	3.96 €/car	0.82 €/m	6 MIG welding cells with 12 robots for small fillet welds (a=2.25 mm) with a length of 4.83 m without welding the structural brackets
2,400,000 €	5.11 €/car	1.06 €/m	6 additional hybrid laser-MIG welding robots for making small fillet welds (a=2.25 mm) at low distortion with a length of 4.83 m while MIG welding the structural brackets
	22.82 €/car		Aluminium top lid, 7 kg x 3.26 €/kg excl. stamping
	To be added		Adhesives for attaching lid to battery tray
500,000 €	10.80 €/car	1.80 €/m	3 flowdrilling robots and 1 lid handling robot
	75.00 €/car		Underfloor, 23 kg x 3.26 €/kg = 75 €/23kg
To be added	To be added		Anodising or painting of extrusions or tray
3,000,000 €	To be added		Helium leak testing
	To be added		Labour, maintenance and training
To be added	To be added		Materials storage and handling system
	To be added		Collating and quality assessment of extrusions
To be added	To be added		Overheads for factory building etc
	To be added		Development and testing
29,600,000 €	**406.44 €/car**		**Total for Materials, Welding and Joining Excluding Labour and Overheads etc**

Table 1: Investment, cost per car and cost per metre

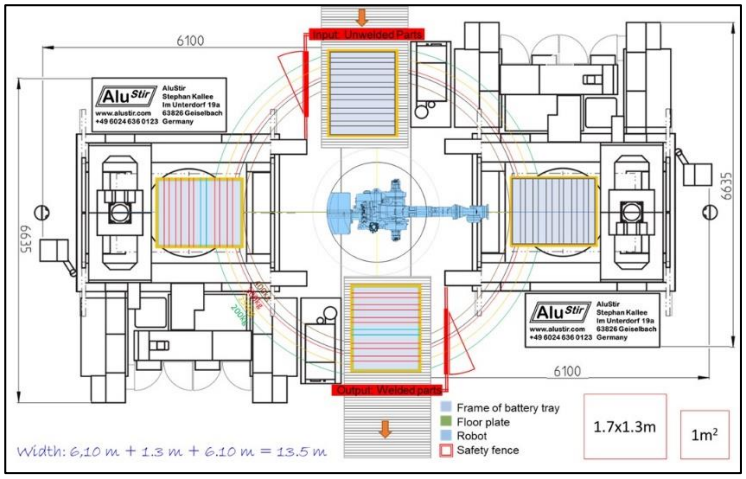

Fig 5: Two FSW machines G-2318 with x-y-z traverse length 2300 x 1500 x 1050 mm and one robot in a 7.5 x 13 m cell