UDC 621

# DESIGN OF TOOL GROOVE FOR PINLESS FRICTION STIR SPOT WELDING BASED ON FIBONACCI SPIRAL CURVE

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Pinless friction stir spot welding represents an innovative solid-state joining technique that has evolved from conventional friction stir spot welding with a pin [1]. In order to enhance the stirring effect of pinless tools and facilitate material flow within the welding zone, researchers often incorporate grooves on the end face of pinless tools [2,3]. However, due to the absence of relevant theoretical guidance, the design of grooves on the end face of pinless tools primarily relies on a trial and error approach. This limitation has resulted in a relatively narrow range of groove types in current use for pinless friction stir spot welding. In order to diversify the types of grooves on the end face of pinless tools and enhance the strength of pinless friction stir spot welds, it is essential to explore novel groove design method.

In this work, we employed a Fibonacci sequence-based Fibonacci spiral curve (Fsc) design for the end face grooves of pinless tools, as illustrated in Figure 1. Initially, the Fsc was constructed using the Fibonacci sequence. Subsequently, the starting point (*S*) and terminating point (*T*) of the Fsc on the end face were determined based on the shoulder diameter of the pinless tool. A semi-circular groove was generated, guided by the curve between points *S* and *T* of the Fsc. Finally, the generated individual groove was evenly arranged in a circular array on the end face to obtain the final shape of the Fsc grooves.

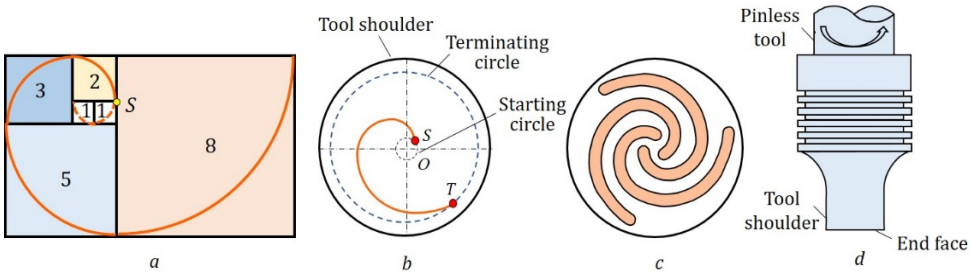


Figure. 1 – Schematic diagram of Fsc groove tool design: *a* –Fsc; *b* – position of Fsc on the end face; *c* – generated Fsc grooves; *d* – main shape of pinless tool

We fabricated the designed tool using H13 steel and conducted friction stir spot welding experiments on 1 mm thick copper sheets. The experimental results were compared with those obtained under typical involute groove tool. The results indicate that the Fsc groove tool exhibits certain advantages in guiding material flow and achieves the highest joint strength. This suggests that the Fsc is effectively applicable in the design of grooves for pinless tools.

**Reference:**

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**3.** Suryanarayanan, R., Sridhar, V.G. Effect of process parameters in pinless friction stir spot welding of Al 5754‑Al 6061 alloys. Metallography, Microstructure, and Analysis. – 2020. – №9 – С. 261 – 272.