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Design and Simulation of a Friction Stir Spot Welding Machine

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Abstract

This project aims to design a Friction Stir Spot Welding (FSSW) machine tailored for welding lightweight metals. Inspired by existing machines, our design prioritizes cost efficiency while maintaining functionality. Initial specifications account for material compatibility and operational needs. The final machine achieves improved weld consistency, throughput, and versatility without excessive cost.

Friction Stir Spot Welding

Friction Stir Spot Welding (FSSW) was invented by Mazda Cooperation in Japan, in 1993. The purpose of FSSW was to address and overcome the challenges typically associated with conventional-spot welding methods. Stages of FSSW can be seen in Figure 1.

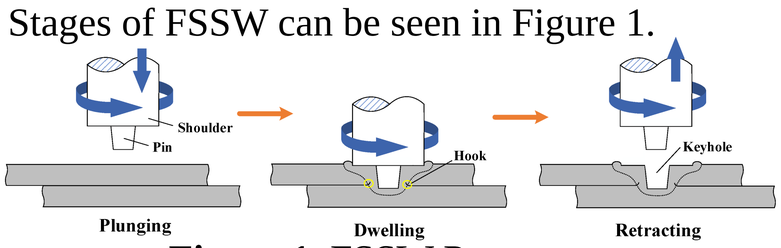
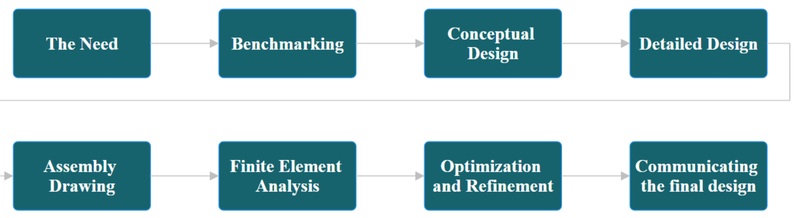


Figure 1, FSSW Process.

Design Methodology



Material Selection

Function	Designing of Spindle Shaft
Constraints	• High strength. • Good machinability • Low notch sensitivity factor. • Good heat treatment properties. • High wear resistant properties.
Objective	Minimize the Cost

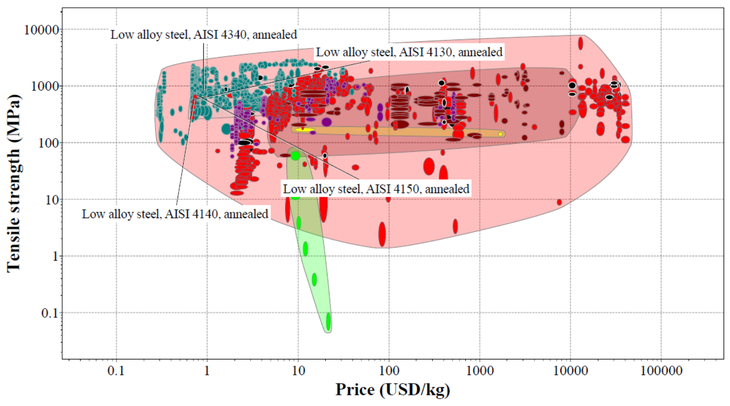


Figure 2, Ashby Plot: Tensile Strength vs. Cost.

Design Procedure

Through a comprehensive benchmarking stage, we initiated the design process by crafting a conceptual design for the FSSW machine, iteratively refining and modifying it multiple times to ultimately arrive at the final design.

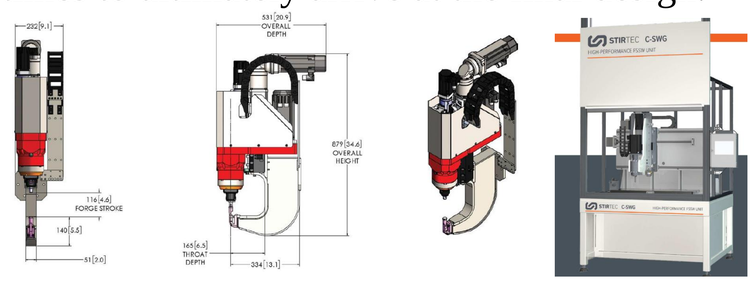


Figure 3, Different FSSW exciting machine.

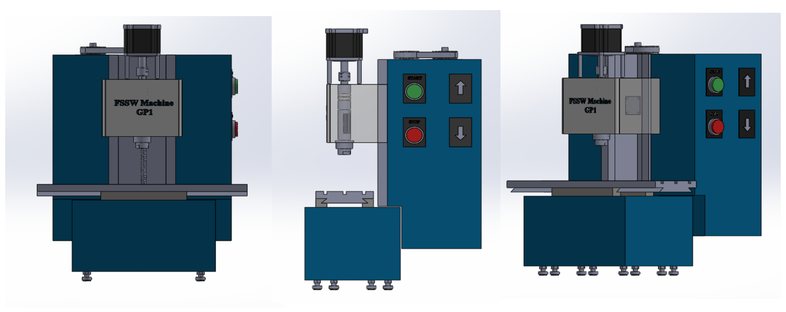
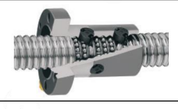


Figure 4, Initial Assembly drawing of the FSSW machine.

Table 1, FSSW machine specifications for initial design.

Downward Force [kN]	20
Torque [Nm]	20-40
Rotational Rate [RPM]	3000-6000

Standard Parts

ISO 40 Tool Holder	
Ball Screw- SKF	
Spindle Servo Motor 7.5 kW	
Ball Screw Servo Motor 4.5 kW	

Machine Specifications

Table 2, FSSW machine specifications for final design.

Downward Force [kN]	10
Torque [Nm]	47.74
Rotational Rate [RPM]	1500-3000
Stroke (mm)	200
Worktable (mm)	800×260

Final Design and Simulation

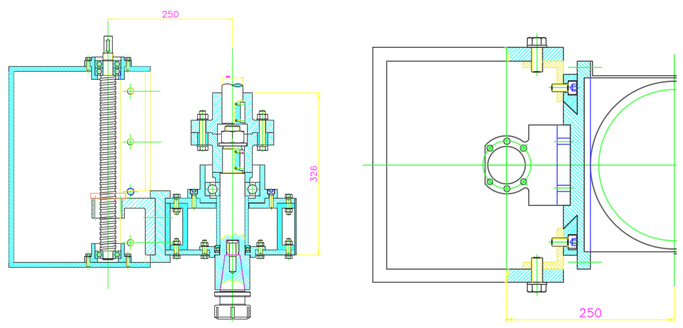


Figure 5, 1st Stage Creating a 2D Sketch.

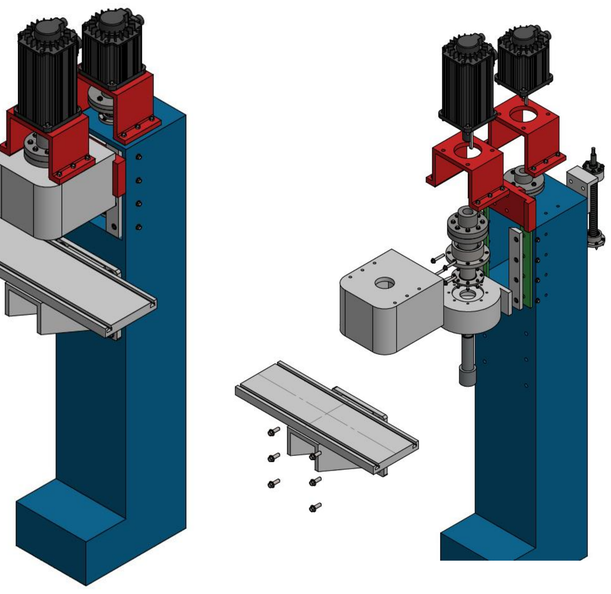


Figure 6, 2nd Stage Generating 3D Model.

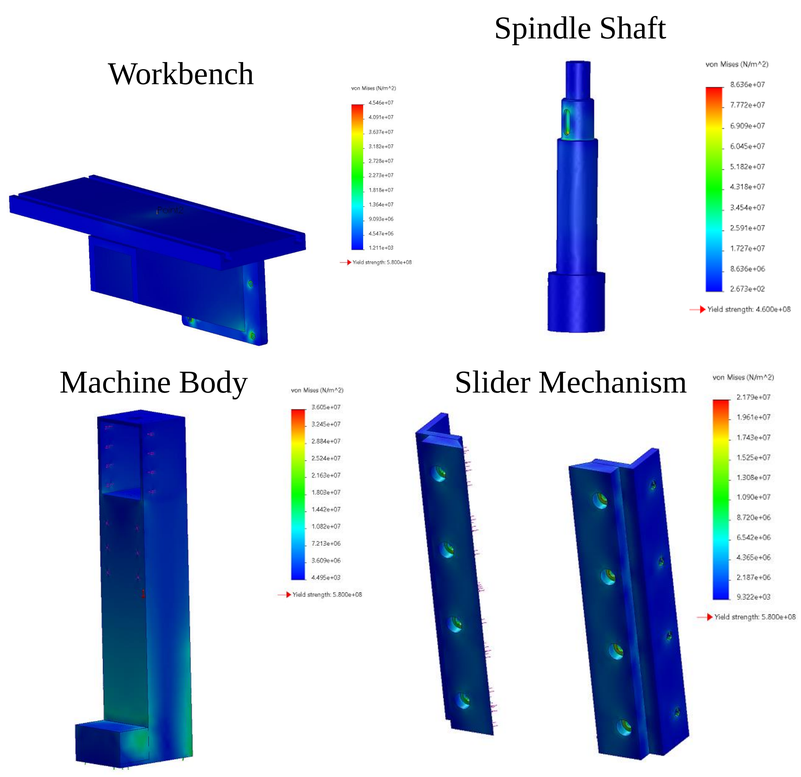


Figure 7, 3rd Stage Applying Finite Element Modelling for nonstandard parts.

Conclusion

Due to their unique properties, lightweight metals pose challenges for conventional welding techniques. This project aims to address these challenges by developing a Friction Stir Spot Welding (FSSW) machine. We have completed the design of the machine and outlined its functionality.