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# Machines and Control Systems for Friction Stir Welding: a Review

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## Abstract:

This survey presents a literature review on the machine and control systems applied in friction stir welding (FSW) with a special focus on the new trends, i.e., using robots and force control. The physical process of FSW is described and the main parameters that are relevant to select a machine and establish a control system are highlighted. The paper reviews in detail the role of the following parameters of a given machine for FSW: force, stiffness, accuracy, sensing, decision-making and flexibility capabilities. They will be compared in terms of the different machines, namely the conventional machine tools, dedicated FSW machines, parallel kinematic robots, and articulated robots. It is stated that articulated arm robots have enormous potentialities in the industrialization of the process, but they also have important limitations namely related to positional accuracy. A quality FSW weld produced by a robot depends on the fine tuning of some process parameters and force/motion control capabilities. Control systems can deal with these limitations. The different approaches to the control systems applied in FSW are presented and their advantages/drawbacks are discussed.

**Keywords:** Friction Stir Welding; Machine Tools; Robotics; Manufacturing; Control Systems.

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