Design of a Portable Friction Stir Welding System and the Development of Active Feedback Controls

Bryan Patton[1], Sylvester Stafford[1], Clay Varner[1], Ryan Crownover[2], Dr. Judy Schneider[1]

[1] Mechanical Engineering Department

[2] Electrical and Computer Engineering Department

Mississippi State University

Preface

Friction stir welding (FSW), a solid state welding process, never ceases to amaze those who are first introduced. Whether it is the thought of joining two pieces of material together without melting or the seemingly effortless way in which the tool mixes solid metal, stir welding will always catch the attention of the newcomer. The benefits of the process include a lack of filler materials, reduced energy costs, and better preservation of the parent material properties.

Problem

Initially patented in 1991, FSW has not yet reached its full potential. Because the process is new and the physical models are lacking, assuring weld quality is difficult. The difficulty stems from the lack of data and experience regarding the influencing factors that govern the weld processes.

What is Friction Stir Welding?

The FSW process is very simple; the probe of a rotating tool is inserted through the depth of the weld panels and travels along the length of the weld seam (Figure 1). The softened material flow reacts against the backing anvil and the shoulder. The shoulder contains the plasticized metal produced by high internal shear forces and deformational heating. The FSW tool, comprised of a shoulder and probe, stirs the weld metal together in the solid state. Although the process was patented in 1991, there continues to be much debate in literature regarding the steady nature of the process and optimal processing parameters.

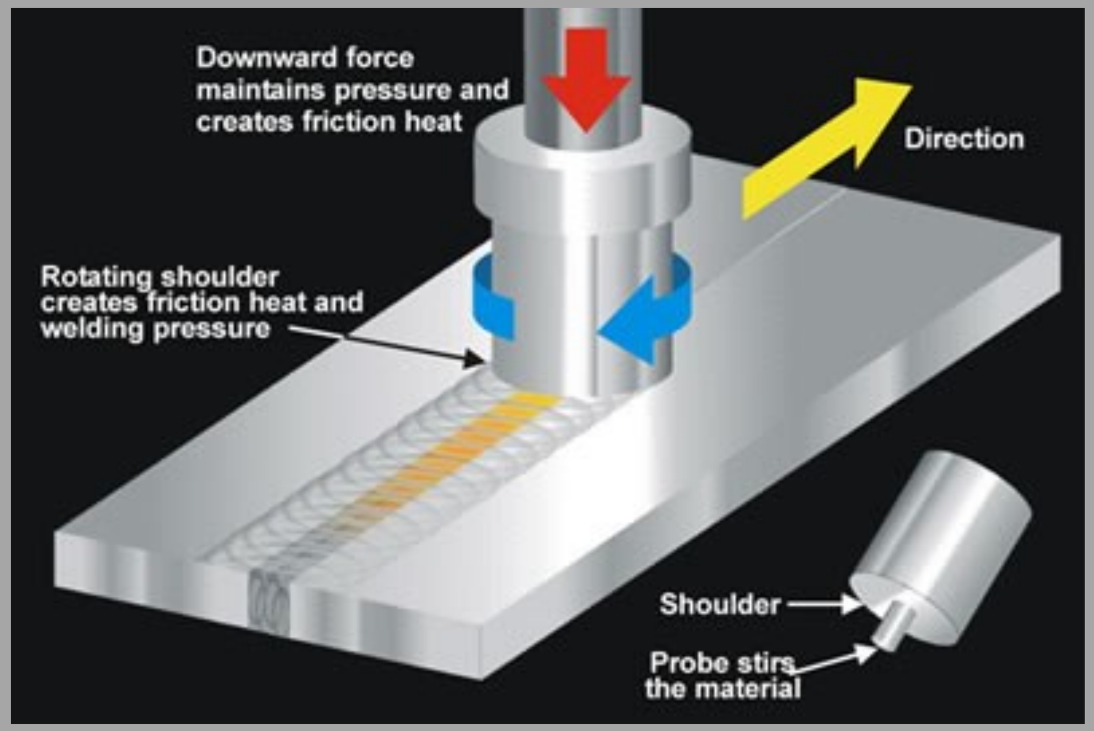

Figure 1. Friction Stir Welding Process (*What is friction stir welding of aluminum?* July 22, 2013. Available: http://www.esabna.com/us/en/education/knowledge/qa/What-is-friction-stir-welding-of-aluminum.cfm)

Solution

In order to improve the quality control of FSW this project team is designing a way to better standardize the welding process by categorizing the parameters as they relate to the changing variables encountered while a weld is in progress. By designing software and hardware that are uniquely capable of interpreting weld data and correcting weld tools in real time separately, this new system can be integrated onto existing commercial FSW machines. The team divided this solution into the two objectives of our project.

The primary objective is to develop a platform which links the collected response data from a weld and adjusts operating parameters in real time. Currently, the process parameters of tool rotation and travel remain constant throughout the length of the weld. By developing closed loop controls for the FSW process, response data will be collected, analyzed, and used to provide feedback instructions to change process parameters *in-situ*.

The secondary objective of this project is to reduce the size and cost of the welding machine to make FSW more available to the public. A portable, low cost option makes FSW available to small businesses, universities, trade schools, and hobbyists who could not initially afford the investment of a traditional FSW machine. With more machines being utilized, a usable pool of data will be collected from the welds, thus aiding in the creation of better control parameters.

Design

The design of a portable friction stir welder presents challenges that our design team chose to tackle on two separate fronts. The first is to create a feedback system and software suite. The second challenge is to design a small machine capable of making a weld. Each challenge was approached with the idea of creating two independent, yet cooperating, systems.

Hardware

In order to make the machine more accessible the team is taking advantage of recent discoveries involving higher RPM operation to reduce the forces required to make a weld. The smaller size (Figure 2) means that the cost of producing the machine will be substantially reduced.

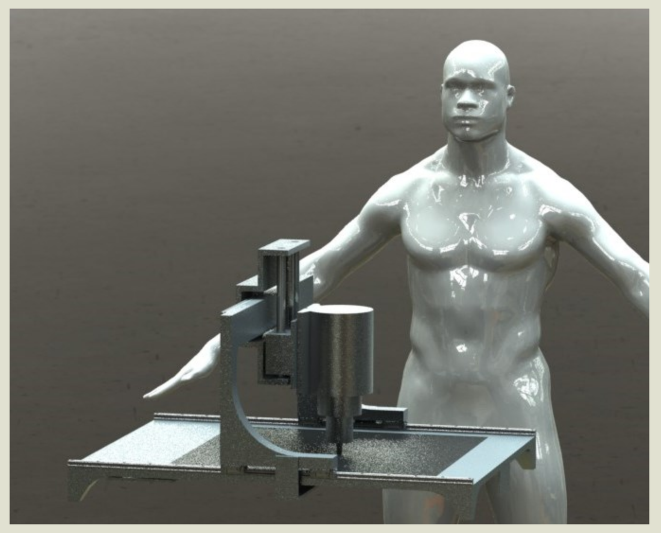

Figure 2. Machine Size Illustration

Thinking Big

In the Spring of 2013, the Bagley College of Engineering's **Think Big** competition offered grants to student teams who had ideas for innovations that could potentially solve world problems. Teams submitted proposals and the college sought out novel ideas and provided them support.

The team presented a proposal that aimed to help rapidly accelerate the development of the stir welding process while also making it more accessible to a wider audience. In May 2013, the team **won a grant of $9,916** in funding to develop our idea.

Conclusion

Once the software and hardware are combined, the resulting system will lay the groundwork for a series of standalone machines and upgrades to existing machines which will allow users access to the cumulative experience of all those using the same welding process. This will both accelerate the development of the welding technique and make the process accessible to new users at a more reasonable cost.

The first step for the team was to secure the funding to allow the development of the prototype. This step was accomplished through MSU's Think Big Program. The next is to find support to continue improving the system until the goal of perfecting this amazing new welding process can be accomplished.

Software

The purpose of the software is not only to create a closed loop logic system, which will produce improving weld quality over time, but also to be completely modular and applicable to all FSW machines in both retrofit and design (Figure 3). The RIF-DD (Real-time Intelligent Fabrication - Development Database) System utilizes real time signal processing, and data acquisition to make FSW machines more intelligent over time. Weld data collected during a job will be continuously analyzed, and the RIF-DD will send corrective instructions to the CNC machine based on a governing equations.

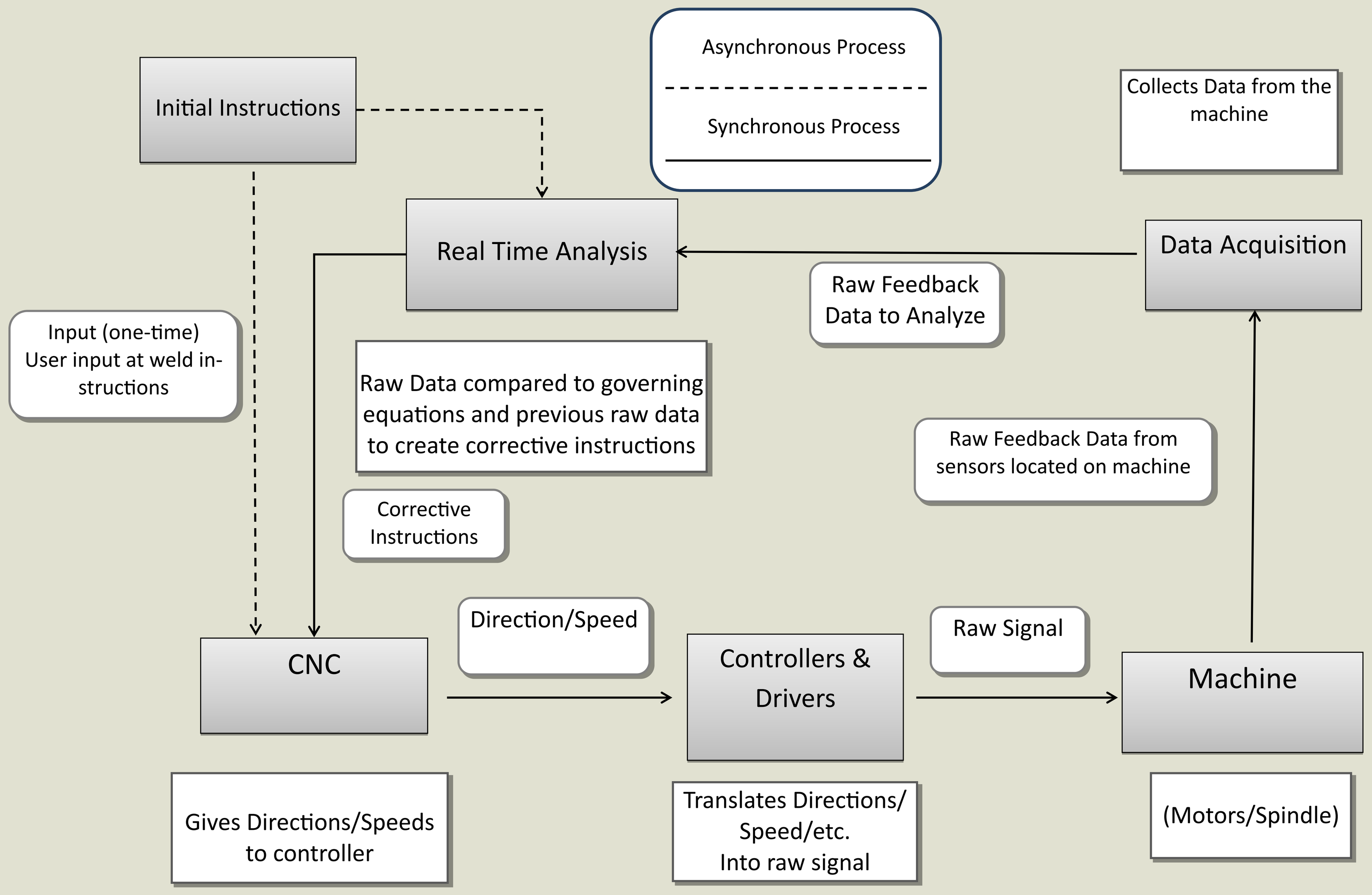

Figure 3. RIFF-DD Data and Control Flow chart