

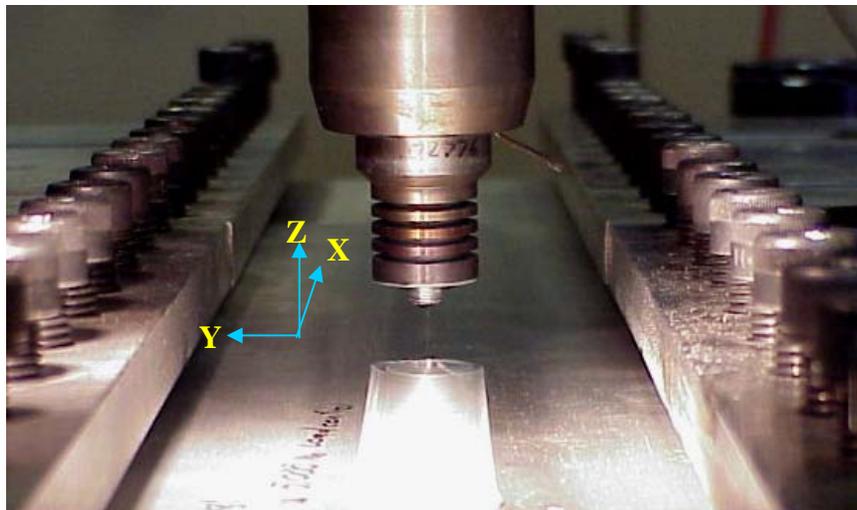
# Effects of Spindle Speed on Welding Forces



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**Objective:** Investigate the various parameter interactions of the FSW process in hopes to build a model of the evolution of heat generation (heat input) via FSW.

**Experimental Approach:** Continuously vary the spindle RPM at different feed rates in Aluminum 7075-T7. All welds were performed by maintaining a constant depth (instead of a constant z-force). Parameters will be varied from 200-800RPM and 2-10 ipm.

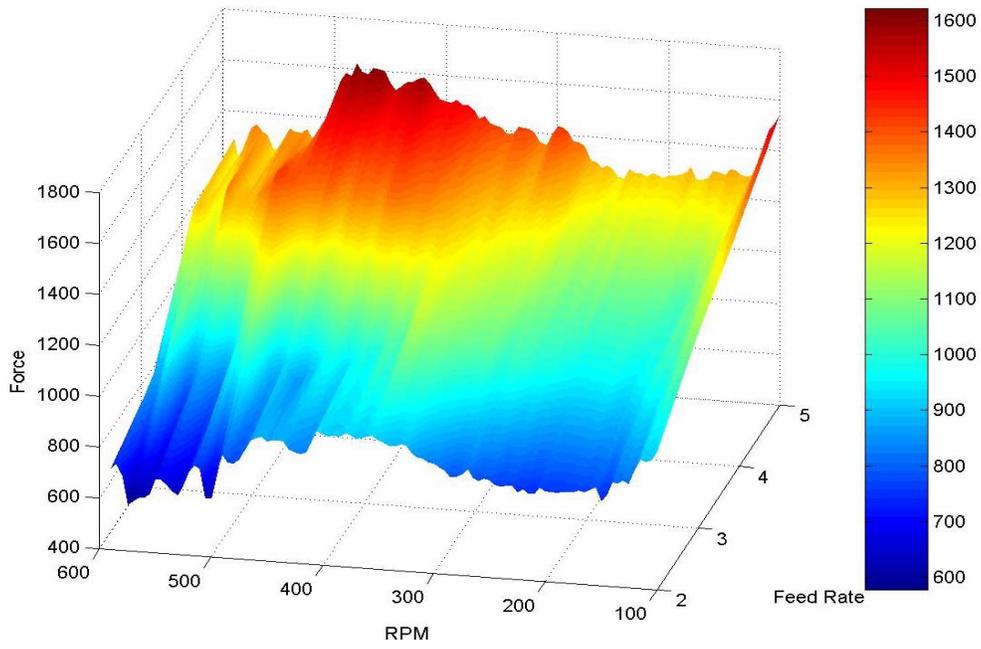


In order to minimize variation in the data, four welds were performed at each feed rate and then averaged together. Two of the four welds were executed increasing the RPM from low to high. The other two were executed decreasing the RPM from high to low.

**Results:** Some interesting trends were discovered to depend heavily on RPM. These are described below.

## **X-Force**

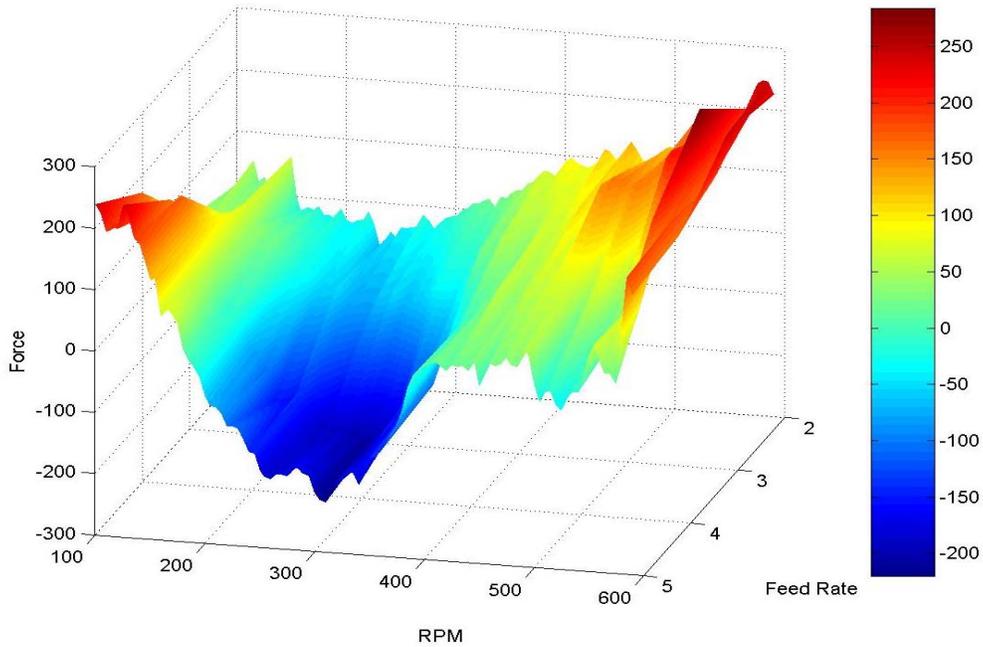
In the x-direction (travel direction), forces are initially high but decrease to a local minimum at about 200-300 RPM for all travel speeds investigated. As RPM increases beyond this minimum, the X-force continuously rises to a local maximum. The RPM at which this maximum occurs are travel rate dependant. Beyond this maximum, x-forces at all travel speeds decrease and become increasing sporadic.



**Figure 1: X-force as a function of RPM and Feed Rate**

### Y-Force

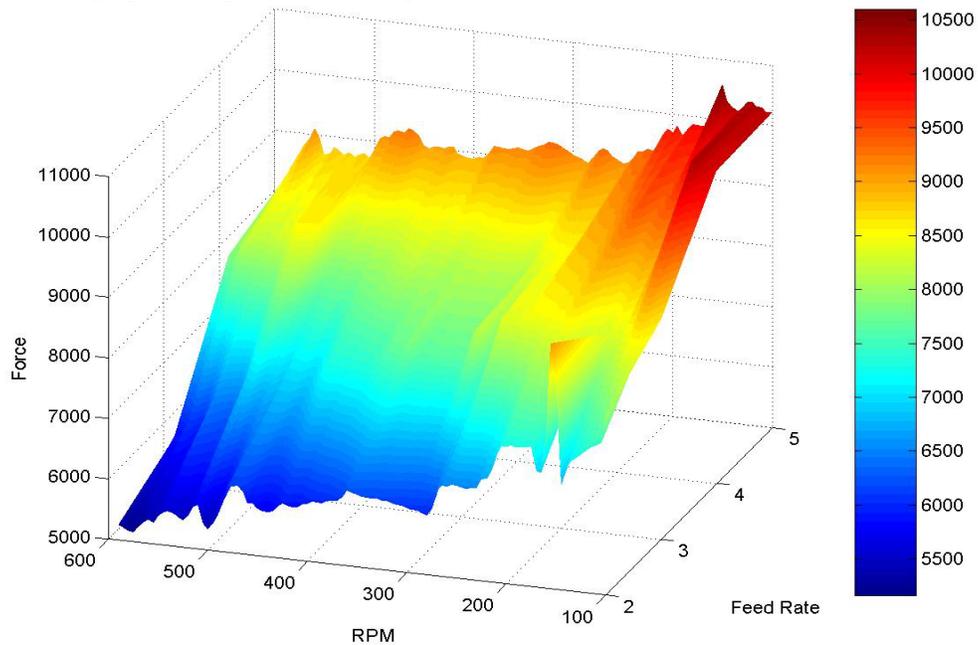
In the y-direction (perpendicular to the travel direction), forces are initially high but decrease to zero around 200RPM. As RPM increases, the y-force returns to its original magnitude, but in the opposite direction. This maximum depends on the feed rate, but falls between 250-300RPM. After reaching this maximum, the y-forces switch back to their original direction, crossing the axis between 300 and 400 RPM. Beyond this point, the y-forces tend to increase at low feed rates and become increasingly sporadic at high feed rates.



**Figure 2: Y-Force as a function of RPM and Feed Rate**

### Z-Force

In the z-direction, forces are initially high at low RPM. The force decreases nearly linearly with increasing spindle speed. The slope of decrease is not the same for all feed rates.



**Figure 3:** Z-Force as a function of RPM and Feed Rate.

**Future Work:** These tests will be expanded in 7075-T7 to include an increased number of feed rates. Thermocouples will be added to trace the behavior of temperature as a function of spindle speed. Also, these same tests will be repeated in 6000 and 5000 series aluminum to verify that similar results can be obtained different materials.