High Speed Welding Defect Formation and Mitigation

Dr. Patricio Mendez, Erik Soderstrom
Colorado School of Mines

In the past several decades, the welding community has seen a tremendous increase in the amount of weld automation. Two reasons for this increase are control and cost savings. High heat intensity processes such as laser and electron beam welding require precision that is unattainable with human control. Not only does automation lead to higher quality welds, but also it increases productivity when compared to their non-automated counterparts. Due to the fact that machines are able to weld at higher speeds with greater control, automated welding can save fabricators a considerable amount of money. However, limitations exist because of the complicated dynamic system that is created during the welding process. Factors such as power, travel speed, shielding atmosphere, electrode geometry and position are all detrimental to the quality of the weld. If any one variable exceeds its acceptable range, defects will form and the laborious task of weld repair must be executed. As manufacturers strive to produce the highest quality weld in the shortest amount of time, a defect known as humping is becoming more prevalent in industry. The goal of this paper is to show how the defects form, the main factors that control morphology, and several ways to mitigate the problem in order to increase travel speeds and overall production.

Humping has been reported in all arc welding processes as well as in laser and electron beam welding. In both electron and laser beam welding, the main mechanism of formation can be explained with a capillary induced humping model. Several researchers including Bradstreet and Gratzke have researched this phenomenon extensively. The model includes the critical length criteria, surface tension effects, as well as heat conduction considerations. The situation becomes more complicated in the presence of an electric arc. Experimental data collected by the current researchers and gathered from published works have been analyzed to show a second model of defect formation proposed as the arc induced humping model. Aerodynamic drag and hydrodynamic forces are the dominating factors in this model.

Several simple changes to the welding process have been shown to drastically reduce humping and can lead to faster travel speeds without the formation of defects. Controlling electrode geometry, shielding gas, and workpiece positioning are the three simplest ways that lead to increased production and cost savings.