Droplet Temperature and Evaporation in GMAW

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The amount of metal evaporated during GMAW is largely controlled by the surface temperature of the molten metal at the tip of the electrode. This temperature is determined by the coupled heat and fluid flow in the liquid metal. The interaction of these two phenomena and its influence on droplet temperature is not well understood.

In this work scaling techniques are applied to the system, it is shown that convective currents can not be ignored, and that they are driven principally by electromagnetic forces. The effect of sulfur content in the filler wire, which affects the Marangoni forces and thermocapillary flows is discussed. Calculations indicate that the surface temperature at the tip of the electrode increases with droplet size. Because of the smaller droplet size, welding in spray transfer mode or with pulsed current vaporizes less metal.

Electrode Tip Droplet Configurations

The surface temperature of the liquid at the tip of the electrode determines the evaporation rate. This temperature depends on the geometry of the droplet, which can be divided into four different configurations:

Configuration I: Condensation of electrons on the wire. Droplet begins to form (Figure 1).In this configuration the anode spot completely covers the droplet and reaches the side of the wire. At the very beginning of formation of the droplet, the molten liquid has the shape of half an oblate ellipsoid, and grows in length as more liquid is molten in the wire. If there is enough molten metal, its starts to have the shape of a droplet, with a diameter bigger than the wire diameter.

Configuration II: Conductive heat transfer (Figure 2). The anode spot covers only a fraction of the surface of the droplet. Heat is transported through the bulk of the droplet by conduction.

Configuration III: Convective heat transfer (Figure 3). The anode spot covers only a fraction of the surface of the droplet. The electromagnetic forces stir the liquid inside the droplet creating two thermal boundary layers (TBL’s) in the liquid, one at the anode (TBLa), and another at the liquid-solid interface with the wire (TBLls). Through the bulk of the droplet, the heat is transported by convection. This is present in the globular transfer mode

Configuration IV: Condensation of electrons on the wire. Droplet stretches into a liquid tail (Figure 4).

The anode spot completely covers the droplet and reaches the side of the wire. The wire melts forming a thin layer of liquid metal through which heat is transported by conduction. The molten liquid extends from the electrode forming a tail. Droplets detach from the tip of this tail. This configuration corresponds to streaming transfer mode

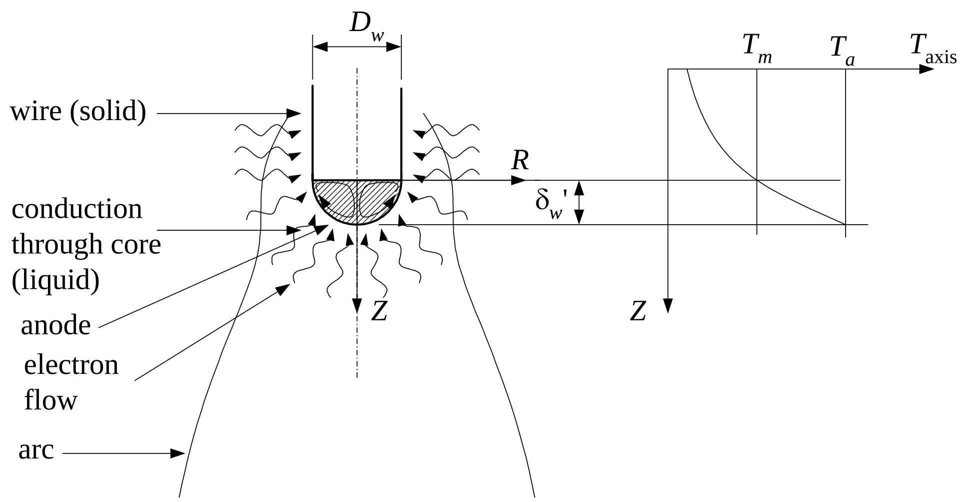

Figure 1: Configuration I (Condensation, beginning of droplet)

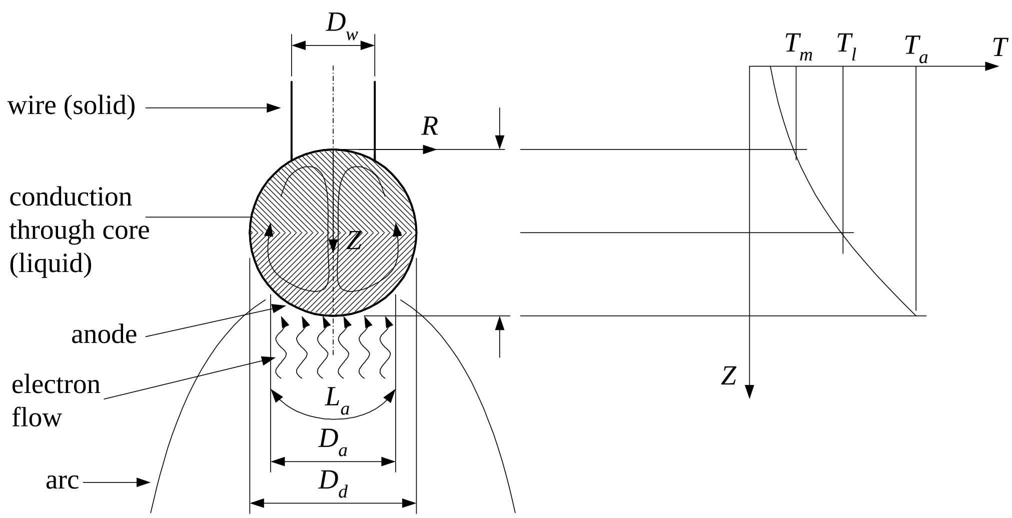

Figure 2: Configuration II (Conduction)

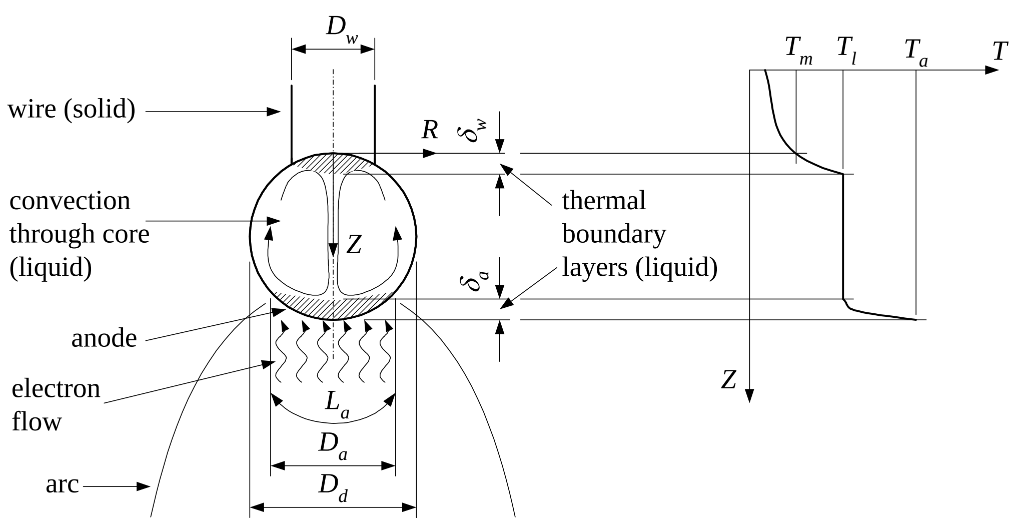

Figure 3: Configuration III (Convection)

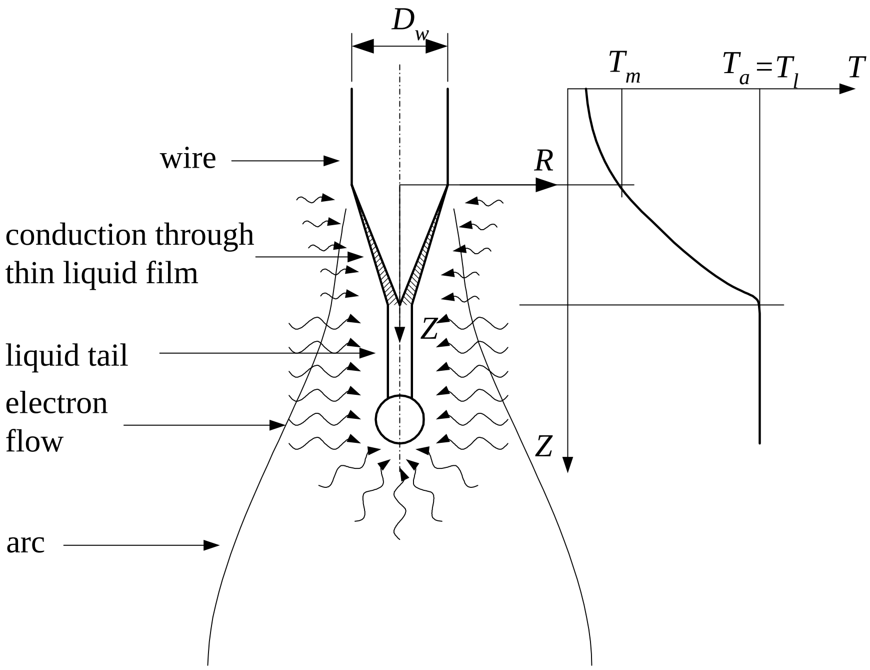

Figure 4: Configuration IV (Condensation, streaming transfer)