

144g Extended Operability Range for Casting by Single Roll Melt Spinning

Cormac J. Byrne, Paul H. Steen, and Steven J. Weinstein

Planar-flow single roll melt spinning is a promising technology for the next generation of continuous casting machines. In the process, a planar nozzle is held in close proximity to a rotating metal wheel or substrate. Liquid metal is forced through the nozzle into the gap region between the nozzle and substrate, and a puddle, constrained by surface tension, is formed. A solidification front grows along the substrate as it translates, forming a solid ribbon (~0.1 mm thick) which is continually ejected from the puddle.

The main control parameters in this process are typically the nozzle-wheel spacing, the substrate speed, and the pressure at which the liquid is injected into the puddle region. However, an extra control parameter can be introduced by adjusting the ambient air pressure along the upstream meniscus relative to that along the downstream meniscus. This additional degree-of-freedom allows a wider operating window for the process. That is, casting can occur under conditions where it previously failed and, where operable, product features can be manipulated in ways otherwise not possible. This additional pressure adjustment is common in liquid-film coating flows but is novel for this type of casting flow. An operating window can be predicted based on the difference in ambient air pressures along the upstream and downstream menisci. The derivation follows the approach used in the coating-flow literature, but the flow regimes are different. In particular, the pressure losses underneath the nozzle in casting flows are predominantly inertia dominated, while viscous effects are usually dominant in liquid coating flows. Additionally, the film-forming region, which is important for liquid-coating windows, is absent in casting due to solidification. The predictions for casting flows will be contrasted with those for coating flows. Experiments testing this operating window and the advantages of the differential pressure system for casting flows will be presented.