Findings:

A simple, yet accurate numerical model of the planar-flow melt-spinning process for Al-7%Si alloys on copper wheels: STRIP1D has been developed. The model include a realistic treatment of fluid flow and heat transfer in the melt pool, coupled with transient heat transfer and solidification of the strip and transient heat conduction within the wheel. Simultaneous predictions of transient strip thickness, SDAS, cooling rate, strip surface temperature and transient wheel temperature have been validated using experimental data measured at Cornell and excellent agreement has been observed. Two- and three-dimensional transient heat-transfer models of the planar-flow melt-spinning process have been developed using ABAQUS and validated with STRIP1D. The effect of process conditions including casting speed, puddle length, gap height, superheat and interfacial gaps on the heat-transfer occurring during this process have been investigated using these models. A method to quantify the surface depressions observed in melt spinning has been developed and validated using experimental measurements which reveals the mechanism of their occurrence. The following conclusions arise from this study.

- The superheat-flux method developed has been validated using multi-dimensional transient heat transfer models.
- Heat transfer across the wheel-strip interface governs solidification in the strip and heat transfer to the wheel. A new time-dependent model for interfacial heat transfer coefficient is proposed.
- In addition to controlling flow rate, and thereby strip thickness, a decrease in gap height seems also to decrease the interfacial heat transfer coefficient, perhaps due to increasing the oscillations in the puddle.
- Strip solidification depends greatly on residence time. As the contact time in zone I increases, the strip thickness increases.
- The observed non-classical strip growth profile for different solid fractions is steep with similar steep temperature contours almost parallel to each other. Also, the strip is mushy even after it enters Zone II and rapidly becomes fully solid near the end of Zone II.
- Parametric studies investigating the effects of various process variables; casting speed, gap height, puddle length, superheat and interfacial depressions on heat transfer have been determined.
- The gap height controls both the strip thickness and the heat transfer from the strip to the wheel, which together determine the puddle length.
- For all other conditions kept the same, an increase in superheat decreases the strip thickness because more heat enters the solidifying strip. If the superheat is very low, the strip might start solidifying at the nozzle resulting in freeze-up.
- Interfacial depressions on the wheel side of the strip interfere with the heat transfer to the wheel and decrease the local solidification rate resulting in an equivalent corresponding depression on the liquid side of the strip.
- The melt-spinning process is flow-rate controlled unlike the strip-casting process, which is heat-transfer controlled where the flow rate is controlled by thickness.
- Together, the STRIP1D and ABAQUS models comprise a powerful tool to study these processes. This work explains the variations in the strip thickness observed in three different time / length scales.
    1. Thickness generally decreases with time during the entire cast, due mainly to decreasing gap height as the wheel expands, and also due to wheel heat-up.
    2. Thickness variations with the frequency of the wheel rotation are caused by gap variations due to slightly non-circular wheel shape.
    3. Small, closely-spaced transverse depressions occur due to the entrapment of air at the strip-wheel interface, owing to oscillation of the melt pool menisci. They can be predicted using a 3-D model that matches experimental measurements.