Reduction of heater power and oxygen content in Si crystals by modification of continuous Czochralski furnace

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This study is expected to find out the well-designed crucible shape and heat shield to improve the quality of 8-inch silicon crystals grown by the continuous Czochralski crystal growth method by performing the numerical simulations. A double crucible is used. The simulation results show that different curvatures of the crucible bottom affect the temperature distribution, oxygen concentration, and the flow pattern. The flat shape of the crucible bottom may reduce the oxygen content along the crystal-melt interface and the heating power consumption in the system. The reduced temperature of the bottom wall of the crucible implies that the pulling rate can be increased during the growth using this crucible design. Also, for this crucible shape, increasing the temperature in the outer melt is beneficial for melting the silicon granules. Moreover, a clearer separation of the flow vortex between the inner and outer melt regions is beneficial in preventing the transport of unmelted granular silicon towards the growing ingot. The thermal stress in the crucible system for different crucible bottom shapes is also calculated. The lowest thermal stress can be achieved by the flat crucible bottom shape. To study the effect of the heat shield shape, the thickness and tilt angle of the heat shield is changed. The adjustment of these parameters varies the argon temperature distribution and flow speed. The melt temperature distribution, the flow pattern, and the heater power are also affected. As the thickness of the heat shield increases, the heater power can be further saved and the oxygen content can be lowered.