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# Cold start mode classification based on the water state for proton exchange membrane fuel cells

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**Abstract:**

The cold start of proton exchange membrane (PEM) fuel cells is one of the primary factors limiting their large-scale commercialization in the automotive field. The water state has a significant impact on the start-up results. Identifying the water state inside fuel cells is the basis for optimizing cold start capabilities and strategies. In this study, the experimental parameters such as current/temperature distribution, cathode pressure drop, and high-frequency resistance of the PEM fuel cell are measured to study water states like local icing and water transport. Based on the above water states, the PEM fuel cell cold-start processes are classified into seven modes, with the thermal equilibrium phenomenon serving as a salient benchmark for the thermal gap. The classification is valuable and general; it can significantly reduce the experimental and time costs of providing targeted optimization directions for the cold start processes of different PEM fuel cells.