



Figure 7.20 Circulation loop through a microwave cavity used for rapid fines dissolution in direct-nucleation control framework of a batch crystallizer. Reprinted with permission from ref. 301, Copyright 2016 American Chemical Society.

For such a system, heat can be added rapidly once fines are detected *via* some *in situ* measurement preventing their growth and, thus, facilitating rapid dissolution. In addition, any conventional heating medium that is used for cooling is not affected by this operation. Therefore, the circulation loop can be designed flexibly and ultimately microwave heating can even be fully integrated within commercially available crystallizer hardware (Figure 7.21).³⁰²

Although the reporting literature on microwave-assisted crystallization is predominantly focused on batch operation, the commercial availability of instrumentation and the vast experience in microwave-assisted chemical synthesis can support the development of future microwave-assisted continuous crystallization processes to achieve PI for industrial crystallization processes.

7.6 New Challenges for Process Intensification in Continuous Crystallization

Pharmaceutical manufacturing is historically dominated by batch processing, which typically takes place in multiple locations for synthesis, purification, and final drug product formulation resulting in prolonged production times and potential supply chain disruptions. On this account, the interest