Polymeric Hollow Fiber Heat Exchangers (Phfhes): a New Type of Compact Heat Exchanger for Lower Temperature Applications

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Plastic heat exchangers are characterized by an inferior thermal performance compared to their metal counterparts. Therefore, their usage is mainly limited to handling corrosive media or when ultra high purity is required, e.g., pharmaceutical industry. Polymeric Hollow Fiber Heat Exchangers (PHFHEs) have recently been proposed as a new type of heat exchanger that can overcome these constraints and offer the same or better thermal performance than metallic shell and tube or plate heat exchangers while occupying a much smaller volume. In this paper we report our results for heat transfer in PHFHEs with both parallel and cross flow in the shell side of the device. Fibers made of polypropylene (PP) and polyetheretherketone (PEEK) were tested. In addition, steam condensation studies in PHFHEs are reported for the first time. Modeling of heat transfer performance of the PHFHEs developed was also performed and will be presented. The modeling takes into account the finite heat transfer resistance of the polymeric wall material. The overall heat transfer coefficients achieved for water-water and water-brine systems are as high as 1500 $Wm^{-2}K^{-1}$. These values are higher than any value reported for plastic heat exchangers and comparable with commonly acceptable design values for metal shell and tube heat exchangers. Similar coefficients were obtained for steam condensation. Polymeric hollow fiber heat exchangers can also achieve high thermal effectiveness (ε), large number of transfer units (NTU) and very small height of a transfer unit (HTU), if properly rated. The value of the thermal effectiveness factor achieved was close to 1, NTU up to 3.9 and HTU as low as 5cm. If designed like commercial membrane contactors, they can achieve up to 12 transfer units in a single device, not longer than 60-70 cm! In addition, the conductance per unit volume PHFHEs achieved was up to $3.5x10^{6}$ $Wm^{-3}K^{-1}$, which is one order of magnitude higher compared to metal heat transfer equipment. This superior thermal performance is also accompanied by considerably lower pressure drops. Therefore, the operation of PHFHEs will be characterized by a low operating cost. Combined with the much lower cost, lower weight and elimination of metal contamination polymer materials offer, it is obvious that PHFHEs constitute a potential substitute for metal heat exchangers on both thermal performance and economical grounds. Possible application fields include the food, pharmaceutical and biomedical industries as well as applications where corrosion resistant, light and very efficient devices are required, i.e., desalination, solar and offshore heat transfer applications.