Evaluation of flow distributor geometry in flow uniformity

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Abstract

Microchemical plants achieve large scale production using several microdevices in parallel arrangement. For this, it is necessary to have flow uniformity through all of them, using for that a flow distributor. Thus, the objective of this work is to analyze the influence of distributor geometry on flow uniformity. Different distributors were manufactured by 3D printing and were submitted to flow tests. It was observed that tapered distributors are more efficient than rectangular distributors and distributors with intermediate heights cause greater uniformity than short or high distributors.

Key words:

Microchemical plants, flow distributor, 3D Printer.

Introduction

Microchemical plants can be defined as plants that use microdevices, such as microreactors (Hasebe, 2004). An example of microplant is shown by Billo et al. (2015), in which biodiesel is produced in a rate up to 2.47 L min^{-1} using 14,000 microreactors. In a microplant, the production increase occurs by the multiplication of equal microdevices in a parallel arrangement (numbering up). The numbering up is strongly related with uniform flow distribution through the microdevices, task that is done by the flow distributor. Bad distributions can be caused by inadequate designs of distributors, reducing the microplant performance. Thus, the flow distributor is very important and contributes for the optimal microplant performance.

Results and Discussion

Rectangular and tapered distributors (Image 1) with internal heights of 13, 26 e 52 mm were used. They were modeled using the software SketchUp and fabricated by 3D printing (Sethi3D Printer, model S3). Each distributor has two inlets and four outlets.

Image 1. Impressed piece and cut view of 3D model: rectangular (a) and tapered (b) distributor.

The experiments were performed with water for different total flow rate (100, 200, 240, 300, 340 and 400 mL min^{-1}) in triplicate. The experiment consists in collect in each outlet a water volume in a determinate time measured by chronometer. For each total flow rate in each distributor the non-uniformity flow coefficient (Φ) (standard deviation of the flow rate for each outlet in relation to the total flow rate) was determined. The results are shown in Image 2 and Chart 1. Lower values of Φ were obtained in tapered distributors, indicating that these ones are more efficient. The flow rate of 100 mL min^{-1} exhibits discrepant Φ , indicating that this flow rate is not recommended for

these distributors. So were calculated two average Φ for each distributor, including and excluding this flow rate.

Image 2. Non-uniformity flow coefficient for rectangular (a) and tapered (b) distributors.

Chart 1. Average Φ for each distributor.

Distributor	Average Φ (%)	
	All flow rates	Without 100 mL min^{-1}
Rectangular 13 mm	12.57	8.24
Rectangular 26 mm	3.01	2.65
Rectangular 52 mm	6.04	4.46
Tapered 13 mm	1.30	1.10
Tapered 26 mm	1.15	0.97
Tapered 52 mm	2.25	1.84

In both averages the tapered 26 mm distributor registered the lowest average Φ . For both geometries lower values of Φ were obtained for intermediate heights (26 mm), what means that flow rates in each outlet have low deviations. Because of this, the flow rates in each outlet are almost constant.

Conclusions

Tapered distributors are more efficient that rectangular ones and the most efficient distributor was the tapered 26 mm. Intermediate heights cause less Φ than higher or lower heights, principally on rectangular distributors.

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