FLOW BEHAVIOUR ENHANCEMENT IN MICRO-CHANNELS

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ABSTRACT

Fluid motions are experienced in nature and technology as well as in our bodies. In our body, blood flow is laminar. However, when the blood flow through semi-clogged or narrowed blood vessels, eddies are formed and thus the blood flow become turbulence. Turbulence is the main contributor to the drag as it increases the loss of energy in the form of friction. Researchers started to have great interest in investigating the feasibility of the addition of a minute amount of drag reducing additives such as soluble polymers into the flow system that resulting in a large reduction of frictional drag in blood streams. In this work, the addition of soluble polymeric additives (Xanthan gum) role as a drag reducing agent (DRA) on the drag reduction (DR) performance using microfluidic devices was investigated. Seven different geometries of Y-shaped micro-channel were fabricated and eight different soluble polymeric additive's concentrations (20ppm to 500ppm) were used used to investigate the concentration effect on drag reduction performance using pressure measurement. The efficiency of the soluble additive was tested using transported liquid (deionised water). The experimental procedure was divided into three parts. For the first part, micro-channel devices were fabricated using soft lithography method and moulded with polydimethylsiloxane (PDMS). The second part was the preparation of soluble polymeric additives solution. Xanthan gum as the drag reduction additive was selected in this study. The last part was to run the whole experiment by using pressure and vacuum pump controller and get the flow rate measurement. The maximum flow increment (%FI) of 34.90% was achieved by utilizing 500 ppm of Xanthan gum at the operating pressure of 100mbar in micro-channel with width of 500µm. The flow behavior of the drag reducing additive into the flow was also investigated using micro particle velocimetry (µ-PIV). Furthermore, our findings proved that the natural polymers warrant further investigation as a drag reduction polymer candidate for potential clinical treatment. It was concluded that the soluble additive are believed to have strong drag reduction properties although they are used in a minute amount.

ABSTRAK

Usul Fluid berpengalaman dalam alam semula jadi, teknologi dan juga dalam badan kita. Dalam badan kita, aliran darah adalah lamina. Walau bagaimanapun, apabila aliran darah melalui saluran darah yang separuh tersumbat atau menyempit, pusaran terbentuk akan menyebabkan aliran darah menjadi pergolakan. Pergolakan adalah penyumbang utama kepada seretan kerana ia meningkatkan kehilangan tenaga dalam bentuk geseran. Kebanyakan penyelidik mempunyai minat yang besar dalam menyiasat kemungkinan penambahan sedikit jumlah bahan pengurangan seretan seperti polimer larut ke dalam sistem aliran yang boleh menyebabkan pengurangan besar seretan geseran dalam aliran darah. Dalam karya ini, penambahan bahan tambahan polimer larut (Xanthan gum) peranan sebagai ejen seret penurunan (DRA) mengenai prestasi pengurangan seret (DR) menggunakan peranti microfluidic. Tujuk *micro-channel* berbeza dalam geometri yang berbentuk Y telah direka-reka dan lapan kepekatan larut bahan tambahan polimer yang berbeza (20ppm kepada 500ppm) telah digunakan untuk mengkaji kesan kepekatan ke atas prestasi pengurangan seret menggunakan pengukuran tekanan. Kecekapan bahan tambahan larut telah diuji menggunakan cecair diangkut (air *deionised*). Prosedur eksperimen telah dibahagikan kepada tiga bahagian. Bahagian pertama, peranti micro-channel telah direka menggunakan kaedah litografi dan dibentuk dengan mengunakan polydimethylsiloxane (PDMS). Bahagian kedua adalah penyediaan larut penyelesaian bahan tambahan polimer. Xanthan gum sebagai bahan tambahan pengurangan drag telah dipilih dalam kajian ini. Bahagian terakhir adalah untuk menjalankan keseluruhan eksperimen dengan menggunakan tekanan dan pam vakum pengawal untuk mendapatkan pengukuran kadar aliran. Peratusan aliran kenaikan (% FI) daripada 34.90% telah dicapai dengan menggunakan 500 ppm Xanthan gum pada tekanan operasi 100mbar dalam *micro-channel* mempunyai lebar 500μm. Kelakuan aliran seretan mengurangkan bahan tambahan ke dalam aliran itu juga disiasat menggunakan *micro particle velocimetry* (μ-PIV). Tambahan pula, penemuan ini membuktikan bahawa polimer semulajadi mewajarkan siasatan lanjut sebagai calon pengurangan seret polimer yang berpotensi digunakan dalam rawatan klinikal. Kesimpulan, bahan tambahan larut dipercayai dapat mengurangkan seret walaupun ia digunakan dalam jumlah yang minit.