

FLOW AND HEAT TRANSFER ANALYSIS ON SPIRAL COUNTER FLOW HEAT RECIRCULATING BURNER

MUHAMMAD FIRDAUS BIN OTHMAN

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To my beloved wife, Nina and
newborn princess Miza

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ABSTRACT

In order to establish a performance characterization of spiral counter flow heat recirculating burner, an understanding of the chemical kinetics, heat transfer and flow dynamics aspects of the combustor needs to be developed. Research would be focusing on the micro-scaled square spiral counter flow configuration which is also known as the “Swiss roll” micro-combustor with propane-air mixture as the case study. A two-dimensional Computational Fluid Dynamics (CFD) with propane-air premixed stoichiometric numerical based model is being adopted and focus of the study would be in observing the thermal characteristic (i.e. heat recirculation rate) of the combustor. This is the parameter that characterizes the preheat energy obtained by the incoming reactants through combustion process and its high energy post-combustion products. The performance of the combustor with respect to the thermal characteristic is being analyzed at a range of $40 < Re < 1000$ steady, laminar and incompressible fluid flow velocity profile. In addition, a parametric study on identifying the effect of different geometrical aspect ratio between channel wall thickness to channel width is also being envisaged. Analysis has shown that a heat recirculation method has managed to produce an excess enthalpy flame beyond the adiabatic flame temperature which leads towards extending the limitation of the combustion process feasibility in a miniaturization of a combustor system.

ABSTRAK

Bagi mewujudkan ciri prestasi penunu aliran bertentangan yang berpusar dengan peredaran semula haba, pemahaman dari aspek kinetik kimia, pemindahan haba dan aliran dinamik pembakar perlu dibangunkan. Penyelidikan ini memberi fokus terhadap penunu aliran bertentangan yang berpusar dengan peredaran semula haba yang berbentuk segi empat dan berskala mikro yang juga dikenali sebagai pembakar berskala mikro “Swiss roll” dengan bahan bakar campuran propana-udara sebagai kes kajian. Kajian melibatkan model berangka pracampur stoikiometrik propana-udara didalam dua dimensi dengan menggunakan kaedah dinamik bendalir berkomputer (CFD) dimana fokus kajian tertumpu kepada ciri terma (kadar peredaran haba) pembakar. Parameter ini menggambarkan tenaga prapanas yang diperolehi oleh bahan bakar sebelum bertindak balas melalui proses pembakaran dimana perolehan tenaga tinggi ini berpunca daripada hasil pembakaran bahan bakar itu sendiri. Prestasi pembakar melalui ciri terma ini dianalisa pada keadaan bendalir yang tak boleh mampat, mantap dan lamina dimana profil halaju sekitar $40 < Re < 1000$. Selain daripada itu, kajian dalam mengenal pasti kesan perubahan geometri diantara ketebalan dinding saluran dan lebar saluran terhadap ciri terma ini turut dijalankan. Analisa telah membuktikan bahawa kaedah peredaran semula haba berjaya menghasilkan lebih entalpi yang melebihi suhu nyala adiabatik dimana ia menjurus kepada memanjangkan had kebolehlaksanaan proses pembakaran didalam pengecilan sistem pembakar.