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碩士論文

噴氣與未噴氣之多孔球/圓柱型燃
燒器流場實驗觀測

Experimental Visualization for Flows over the
Porous Spheres and Cylinders with/without
Blowing

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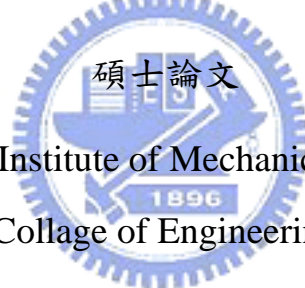
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噴氣與未噴氣之多孔球/圓柱型燃燒器流場實驗觀測

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摘要

本論文採用兩種型式之多孔燃燒器在風洞中進行流場觀測實驗。實驗主要是利用煙線產生及以雷射光頁為光源的方法來觀測燃燒器在冷流流場中所造成的流場型態。實驗的參數為風洞進氣速度(亦為雷諾數)和燃料(空氣)噴出速度，以及燃燒器的幾何因素。本流場觀測實驗主要分成兩個部分。第一部分是針對未噴氣的燃燒器進行觀測，將獲得的實驗結果用來比對先前學者的相關研究，進而驗證本實驗的正確性。並且觀測得知在同一進氣速度下，圓柱型燃燒器的分離點與前滯點的夾角會比球燃燒器小，此歸因於流經圓柱的流場受到較大的摩擦力。第二部分則為主要的研究領域，亦即針對噴氣中的燃燒器其對流場型態的影響。在本論文裡將針對每個燃燒器在一固定的燃料噴氣速度下，其相對於不同雷諾數下的流場型態做詳細敘述，並找出各燃燒器的不同燃料噴氣速度及其所對應的臨界進氣速度的關係式。其中臨界進氣速度則是指被吹離的尾流接回燃燒器表面時的風洞進氣速度。最後，將本實驗所觀測的冷流流場實驗結果用來比照相同雷諾數下的火焰型態，即吹離火焰轉變為第二尾焰，而幫助了解其背後的物理機制。

Experimental Visualization for Flows over the Porous Spheres and Cylinders with/without Blowing

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ABSTRACT

This thesis carries out the experiments to visualize the flowfields over burners in a wind tunnel. The smoke-generation wire and laser-sheet lighting are employed to visualize the cold flow behaviors over the burners. The parameters are incoming flow velocity (i.e. Re), blowing ejection velocity and geometric variations of burner. The cold flow visualization consists of two parts. The first one is to visualize the flow behaviors around and behind the burners without air blowing. The resultant patterns are eventually confirmed by the relative literatures. The separation angles as a function of Re for each burner are measured. It is found that the occurrence of separation for the cylinder is earlier than that for the sphere with the same diameter. It is attributed to that the flow is subjected to more frictional force in the cylinder case. The second part is to investigate the effect of the blowing from burners on the flow behaviors. The flow pattern for each burner with a fixed air ejection velocity (V_w) is described in details. For the case of 15mm-diameter cylinder, it is found that as V_w is set at 1.76 cm/s, the wake does not approach to the cylinder surface until Re increases to 907. Similarly, for the 20mm-diameter cylinder under the specified V_w of 1.32 cm/s, the wake returns to the rear of burner as Re approaches to 1,057. As to the sphere burner, the critical value of Re is 1,720 under the specified V_w of 4.72 cm/s. Moreover, for these three different burners, under the various

V_w at the critical incoming flow velocity (U_{in}), above which the wake returns to the rear of burner, are observed. For each burner, V_w and critical U_{in} are correlated into an equation, respectively. Finally, the cold flow structures can partially correspond to the resultant flame behaviors, which the lift-off flame is transformed into second wake flame, at the same Re .



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NOMENCLATURE

a	Length of the cross-section area of test section
A	Cross-section area of test section
$A_{c,B}$	Surface area of cylinder burner
$A_{s,B}$	Surface area of sphere burner
b	Width of the cross-section area of test section
D	Diameter of the cylinder or sphere burner
D_i	Inner diameter of the burner
D_o	Outer diameter of the burner
L	Length of the cylinder
Re	Reynolds number
T	Temperature
U_{in}	Incoming flow velocity
\dot{V}	Volumetric flow rate
\dot{V}_0	Flux of air
V_w	Fuel ejection velocity
ν	Kinematic viscosity

Greek Symbol

ρ	Density of incoming air (300K, 1atm)
μ	Viscosity of incoming air (300K, 1atm)
θ	Separation angle