國立交通大學

機械工程學系

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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Submitted to Institute of Mechanical Engineering

Collage of Engineering

National Chiao Tung University

In Partial Fulfillment of the Requirements

For the degree of

Master of Science

In

Mechanical Engineering

June 2004

Hsinchu, Taiwan, Republic of China

中 華 民 國 九 十 三 年 六 月

誌謝

給我最愛的家人，感謝爸媽長久以來對於我所追求的夢想無條件的支持與付出，在你們奮力張開的羽翼下，我始能無憂無慮地成長茁壯。感謝大姐、哥、二姐、姐夫，有你們全力的支持，才讓我在求學路上更有勇氣。給已逝的小叔叔，我會永遠記得你對我的期許。

感謝我的指導教授，陳俊勳老師，謝謝老師在學生兩年的研究過程中耐心的教導，並犧牲休息時間協助學生完成論文的著作。對於老師的諄諄教誨，學生謹記在心。

感謝從小一起長大的好友，米粉，因為妳一直都在，才讓我的情緒有個出口。

感謝好友阿伯，希望我們往後的同學會都還能全員到齊。

感謝燃燒防火實驗室的大家豐富了我的實驗室生活，博班學長柴博、國光、晨瑋、文奎、文耀及大達，碩班學長勇任、繼中、王董、家銘，學弟耀慶、奕雄、亞叡、俊衡。尤其是勇任學長及耀慶，你們對於我實驗研究上的幫忙，我深感於心。最重要的，感謝我的夥伴們，皓然、平吉、德正，這兩年來我們一同修課、熬夜寫報告、準備考試，互相加油打氣，這樣的革命情感讓我們的友情更堅定。感謝雅雪，常常因為有妳的傾聽及鼓勵，我才不至於低落太久。

感謝我的室友怡芬，這兩年來多虧有妳在生活上的照顧以及包容，讓我能專心的完成實驗。

感謝我的大學同學們，怡秀、雅慧、旻鍾、俊憲、小胖、建成、佩宗、長佑以及未提及的大家，因為你們，我擁有一段精采的求學過程。

最後，感謝好友佳鴻，因為有你毫不保留的幫助，我才能順利完成實驗。也謝謝你陪我度過這一年多本來應該很無趣的研究生生活，讓我充滿回憶。

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的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.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

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
v	Kinematic viscosity

Greek Symbol

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