

國立中興大學機械工程研究所

碩士論文

指導教授：盧昭暉 博士

定容預混火燄缸壁熱傳分析與量測

Analysis and Measurements of Premixed Flame
Wall Heat Transfer in A Constant Volume
Chamber

研究生：段成龍 撰

中華民國八十三年六月十八日

中文摘要

本實驗主要針對預混火燄在定容室內熱傳現象分析與量測，其目的是在一個簡單且可控制的環境中探討一些基本的參數對缸壁與火燄間熱傳的影響。

在實驗量測方面，本實驗建立了一套可量測瞬時熱傳量的定容燃燒室設備，並進行一些基本量測。量測結果顯示，在當量比0.9至1.3時，定容室中發生爆震現象。此現象引起壓力振盪，此振盪頻率為0.75、1.5、2.25與3.0KH_z。火燄到達端壁後，熱傳迅速上升，然後開始下降，但下降後又會有振盪起伏發生，且在不同測試中，此振盪頻率都很一致。在當量比1.1時，熱傳量有極大值。而沿著側向壁面不同位置量測熱傳，發現當火焰通過時及當壓力迅速上升時，熱傳都會急劇增加。

在數值計算方面，本文分別採用一維的層狀火燄模式與準維的熱力學方法模擬定容室內火燄傳播過程及壓力、溫度與熱傳量的變化。並使用無因次化參數，將數值計算結果與實驗量測結果加以比較。比較結果顯示，在定性方面，有關熱傳量與壓力的關係及熱傳量與火燄到達端面所需時間的關係均相當吻合。在定量方面，因定容室中層流火燄已轉成紊流火燄，為求於同一比較基礎下進行討論，故使用無因次化的方法，且經過無因次化後，量測與計算的熱傳量就很接近。

ABSTRACT

The heat transfer of premixed flame in a constant volume chamber was analyzed and measured in this experiment. The objective of this research is to investigate the parameters that affect the heat transfer between the wall and the flame under a simple and controlled environment.

A constant volume chamber system was set up to measure the instant heat transfer as flame passed over the wall. Results of measurement show that knock occurs in this chamber when equivalence ratios are in the range of 0.9 to 1.3. Knock caused pressure oscillations with frequencies of 0.75, 1.5, 2.25 and 3.0k Hz. After the flame arriving at the wall, the heat transfer rises quickly and then decays. During the period of decay, heat transfer oscillates with the frequency of 200 Hz. These frequencies are the same for all the conditions tested in this study. The heat transfer has its maximum value at the equivalence ratio of 1.1. Moreover, as the flame travels along the wall of the chamber, the side wall heat transfer has two peaks, one occurs at the time the flame passes, and the other occurs at the time when the pressure in the chamber increases abruptly.

A one dimensional laminar flame model and a quasi dimensional thermodynamic model were used in this paper to simulate the process of flame propagation in the chamber. The chamber pressure, the flame temperature and the end wall heat transfer were calculated, and the predicted pressure and heat transfer were compared with the measured data. Results of comparisons are discussed as follows, Qualitatively, the measured relationships between the maximum heat transfer and the peak pressure, the equivalence ratio, and the time for the flame to travel in the chamber are in fairly good agreements with those predicted by calculations. However, since the flame in the chamber has transferred from laminar to turbulent, the quantitative comparisons are not good in terms of the maximum value and the time scale of heat transfer. However, after normalization, the measured heat transfers are close to predicted ones.

目錄

中文摘要	I
英文摘要	II
致謝	III
目錄	IV
表目錄	VII
圖目錄	VIII
符號說明	XIII
第一章 緒論	1
1.1 前言	1
1.2 定容燃燒室中火焰傳播現象	3
1.3 文獻回顧	3
第二章 定容室中準維與一維層狀火燄模式	8
2.1 前言	8
2.2 一維層狀火燄模式	8
2.3 準維火燄傳播模式	15
2.4 準維與一維模式計算結果之比較	20
第三章 實驗量測裝置與設備	21
3.1 定容燃燒室	21
3.2 瞬時熱傳與壓力量測裝置	22

3.3 燃料與點火系統.....	24
3.4 數據擷取系統.....	25
3.5 測試臺.....	26
第四章 實驗原理與方法.....	27
4.1 測試程序.....	27
4.2 當量比控制.....	29
4.3 瞬時壁面熱傳率計算.....	30
4.4 瞬時壓力量測.....	36
4.5 重覆性分析.....	36
4.6 實驗量測誤差.....	38
第五章 結果與討論.....	40
5.1 量測結果之現象描述.....	40
5.2 溫度計的影響.....	41
5.3 爆震的影響.....	42
5.4 當量比的影響.....	43
5.5 不同量測位置的影響.....	46
5.6 實驗結果與數值計算比較.....	48
第六章 結論及未來研究方向.....	53
6.1 結論.....	53
6.2 未來研究方向.....	55
參考文獻.....	57

附表	63
附圖	69
附錄A 電子電路	110
自述	116