國立中興大學機械工程研究所

碩士論文

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單缸二行程引擎循環模擬與排氣噪音之分析與量測

Measurements and Analysis of the Performance and the Exhaust Noise of Single Cylinder Two Stroke Engines

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摘要

本文主要是進行單缸二行程機車引擎排氣管內的壓力與排氣噪音計算，並比較量測結果。本文模擬引擎點火運轉時，在眞實複雜排氣管內的壓力變化以及排氣氣流所產生的噪音，並以此來計算排氣出口二公尺外的總噪音量及噪音頻譜分佈。

在本文中以零維模式來模擬汽缸內驅排氣及壓縮過程，以準維模式來模擬燃燒過程，而以一維模式來模擬進排氣管內的流速與壓力變化。其中進排氣管內的一維可壓縮流是以特徵線法來解。至於排氣噪音計算，則假設在排氣管出口處爲一點音源，由該處的瞬時速度可計算出排氣管外的音壓，文中並考慮地面反射的影響。由於眞實排氣管是由數個膨脹室及連通管所組成，構造複雜，本文中以三種不同方法來建立排氣管模型，分別爲單一膨脹室法，多膨脹室法，及連通管法，並進行六種不同引擎運轉狀況下的計算。由計算與量測結果的比較可發現，在壓力比較方面：引擎在低轉速時，三種方法都能得到合理的壓力變化，但引擎在高轉速時，使用連通管法較能掌握排氣管內高頻的壓力變化。在噪音比較方面：引擎在低轉速時，三種方法可得到合理的總噪音量及頻譜分佈。但在高轉速時，在 400 Hz 到 1000 Hz 之間，本模式低估噪音量，而在 3000 Hz 以上，本模式則高估噪音量。整體而言，連通管法較能掌握整個引擎的特性。

本文亦以 WAVE 軟體進行同一具引擎的排氣管內壓力與排氣噪音計算與量測，並比較六種不同引擎運轉狀況下的計算結果，本文以 WAVE 方式亦將排氣管分割成三種不同排氣管模型。由計算與量測結果的比較可發現，壓力的預測比量測多了高頻壓力波，在低轉速時高頻壓力波愈激烈。噪音頻譜的預測在 100 - 400 Hz 還不錯，但低頻偏低而高頻偏高，而在總噪音量方面則第三種切割方式很接近量測值。

Abstract

In this paper , the calculations and measurements of the pressure variations in exhaust pipe and the noise emitted from the tail pipe in a commercial single cylinder , 50 c.c. , two stroke , crank-scavenge type engine were done . The real exhaust pipe and engine firing running condition were used . The comparisons of both calculations and measurements were done for testing the models of the prediction .

In modeling the engine cycle , a zero dimensional thermodynamic model was used to represent the compression and the expansion process in cylinder . And a two zone quasi dimensional model was used to represent the combustion process . As for scavenging process , the perfect mixing model was used . In modeling the gas dynamics in the intake and the exhaust system , an unsteady one dimensional model was used , and the characteristic line method was employed to solve the partial differential equations . As the real exhaust pipe , which is composed of three expansion chambers and four connecting tubes , has complex geometry , there are three divided methods used in the exhaust pipe for analysis . They are simple one chamber method , muti-chambers method and connecting tube method . There are six engine running conditions used for comparison . In the calculated results , for pressure variation , the three divided methods can get quite better prediction in low engine speeds , but in high engine speeds , the connecting tube method has better prediction . For noise prediction , there are also good prediction in low engine speeds , but in high engine speed , three methods have low prediction during 400 Hz 1000 Hz , and high prediction during upper 3000 Hz . In one word , the connecting tube method can get the engine properties clearly .

In the other way , the 'WAVE' simulation is used to compare with the measured results with the same engine . There are also three divided exhaust pipe methods using the 'WAVE' divided style . In the calculation results , there are high frequency pressure variations inside the exhaust pipe , the lower engine speeds , the high frequency pressure variations serious . Between 100 Hz and 400 Hz , the noise prediction quite better , but , in low frequency , noise prediction is lower than the measured data and is higher than the measured data in high frequency . In the overall sound pressure level , the third method has the better prediction than others .

目 錄