國立中興大學機械工程研究所

碩 士 論 文

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單膨脹室排氣管內流場之量測與分析

The Measurement and Analysis of the Flow in the Single Expansion Chamber Exhaust Pipe

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中文摘要

排氣噪音是機車相當重要的噪音來源，而排氣噪音與引擎排氣管內的瞬時流場變化很有關係。過去在分析排氣噪音時，都使用一維非穩態可壓縮流模式來計算排氣管內的流場，這種做法固然能掌握一些排氣噪音特性，但因真實的排氣管形狀十分複雜，一維理論有其限制，往往會低估高頻噪音。本研究主要是探討引擎在固定轉速運轉時，複雜排氣管內的瞬時流場變化。本研究以多維非穩態氣體動力學模式來取代現行的一維模式，並與引擎循環模擬分析模式結合，計算複雜排氣管內的流場，以了解引擎排氣系統設計參數對排氣噪音的影響。

本研究以計算與量測同時進行。在計算方面，本研究利用 BOOST 軟體建立二行程機車引擎模式，其中進氣系統及驅氣道為一維模式，曲軸箱及氣缸為零維模式，再以 FIRE 軟體建立軸對稱二維的排氣管模式；並將一維與零維的引擎模式與二維的排氣管模式結合起來，同時進行計算，以獲得單膨脹室排氣管內在整個引擎循環過程中速度與壓力的周期性變化。在實驗方面，本研究以馬達帶動一具單缸二行程機車引擎，配合單膨脹室排氣管進行定轉速量測，本研究使用熱線流速儀來量測排氣管內冷流場的速度變化，並使用壓力轉換器來量測排氣管內壓力變化。

計算結果顯示使用一維與二維模式在計算排氣管內流場時會有很大差異，當排氣管流場達到周期性穩定狀態後，膨脹室的突張與突縮段會有兩個迴流區域產生，而這兩個迴流區會相互消長，又合併成一個繞著整個膨脹室的大迴流，如此不斷地循環著，這是一維模式所無法看到的。而在壓力變化方面一維與二維模式的計算結果很接近。至於在連接引擎與排氣管及連接排氣管與大氣的直管內，流場變化與壓力變化都很接近一維。

ABSTRACT

Exhaust noise constitutes the major part of the total noise emitted from motorcycle engines, especially for two stroke engines with small displacement volume. The temporal variations of the velocity and pressure inside the exhaust pipe play an important role in determining the total sound pressure level and the spectral characteristics of exhaust noise. Usually one dimensional unsteady gasdynamic model was adopted to calculate the exhaust flow in the past. This approach worked well for exhaust pipes of simple geometry. However, high frequency components of the noise generated from exhaust flow could be underestimated for complex exhaust pipes with the conventional one dimensional approach. The objective of this research is to investigate the flow characteristics in the exhaust pipe of a small two stroke motorcycle engine. A multi dimensional flow model coupled with an engine cycle model was used instead of the conventional one dimensional model to calculate the periodic flow in exhaust pipes.

Both analysis and measurements of the temporal variations of the velocity and pressure variations inside the exhaust pipe were carried out in this study. The engine cycle simulation software BOOST was adopted to model the two stroke motorcycle engine. The intake system was analyzed with one dimensional model while the crankcase and the cylinder were analyzed with zero dimensional model. A CFD package FIRE was applied to model the three dimensional periodic flow in the exhaust pipe. The three dimensional exhaust pipe model and the one/zero dimensional engine model were then combined together and the associated numerical programs were executed

concurrently to obtain the periodic variations of the pressure and flow in the exhaust pipe. As in the part of measurement, a commercial moped engine was used for testing in this study. An exhaust pipe with single expansion chamber was attached to the engine exhaust port. The engine was driven with an electric motor at constant speeds. The temporal as well as the spatial variations of the flow inside the exhaust pipe were measured with a hot wire anemometer and the pressure variations were measured with pressure transducers located at several locations along the axial length of the exhaust pipe.

Results of calculation of the three dimensional exhaust pipe model showed that as the flow in the exhaust pipe reached a stable periodic state, two circulating zones occurred in the expansion chamber. These two circulating zones grew and decayed sequentially and then merged together to become a large circulation at the end of an engine cycle. The process of growth and decay repeated in each engine cycle. Calculation results of the three dimensional exhaust pipe model were quite different from those of the one dimensional exhaust pipe model obtained previously. The complex flow pattern occurring inside the expansion chamber has not been observed in the results of conventional one dimensional exhaust pipe model. However, the pressure variations in the exhaust pipe obtained from the conventional one dimensional model are close to those obtained in the present study. The spatial pressure variations in the expansion chamber are within 0.1 kPa at all times during the flow period, and the pressure distribution along the length of the pipe is close to a plane wave. As in the straight pipe connecting the engine exhaust port and the muffler, the calculated velocity distribution in the present study was close to that obtained from previous one dimensional calculation.

Comparing the measured data with the calculated results showed that the location and the moving speed of the circulating zones as well as the major frequency components of the velocity variations in the expansion can be predicted correctly. However, the calculated velocity amplitudes and phase angles did not agree very well with the measured data. As comparisons of the instantaneous flow at the exit of the exhaust pipe, results of the three dimensional model are closer to the measured data than those obtained from the conventional one dimensional model concerning the velocity amplitudes and phase angles. However, discrepancies of the average flow in the whole cycle still exist between the calculated results and the measured data for both the cases of one dimensional model and three dimensional model.

目錄